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OBSESSION

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Psychology
Why we should take the loss of a pet more seriously

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I made my coffee too strong and now it feels like my heart is being punched by a gorilla. Can anything reverse the effect? →p77

FROM THE EDITOR

I get bored easily. I think that's why I've never become *truly* obsessed with anything. There's just something about novelty, the little fireworks that go off in your brain when you learn something new, that means I've never had a singular hobby or lifelong pursuit. It's probably why I've spent more than a decade working on this magazine (I suppose some might call that a small obsession) without getting bored – I learn something new every day.

But I do know someone with an obsessive personality. They can work on a single idea for months, years, or even decades, without getting bored or distracted. They replay the same 20-year-old video game year after year. They'll happily rewatch the same movies, over and over. They love cycling so much that the bike even comes on the family holiday in its own suitcase. The list goes on. In some ways I'm envious. They're an engineer by trade, so their tendency to become obsessed has positive outcomes: they've built their own home office and workshop in the garden, they meticulously design and build their own furniture, they've even built their kid their own dream bedroom. I, on the other hand, get bored halfway through a Lego instruction manual.

So what causes some of us to latch onto an idea or an interest in a way that it becomes an all-consuming passion? And is it just dumb luck that some obsessions lead to pursuits that society deems healthy – like becoming an Olympic medal-winning athlete – while others can cause a neverending loop of negative thoughts? What is it that means some people find it hard to let go? Over on p60, Helen Glenny digs into the science.

Daniel Bennett, Editor

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CONTRIBUTORS

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CONTACT US

Advertising
David.DSouza@ourmedia.co.uk
0117 300 8110
Letters for publication
reply@sciencefocus.com
Editorial enquiries
editorialenquiries@sciencefocus.com
0117 300 8755
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ON THE BBC THIS MONTH...

The Climate Question: Why Does The Earth Not Warm Evenly?
In some parts of the Arctic, warming is happening five to seven times faster than anywhere in the world. In certain regions of the Middle East and Africa, warming is two times higher than the global average. This show explains what's driving these differences.
BBC World Service
23 January, 9:30am
Also available on BBC Sounds

Born In Bradford
Born In Bradford is one of the largest research studies in the world. The study is tracking thousands of children's mental health with the aim of improving their lives with targeted interventions. Find out whether this breathtakingly ambitious piece of research will actually work.
BBC Radio 4
22 January, 1:30pm
Also available on BBC Sounds

The Secret Genius Of Modern Life
Bank cards, fitness trackers, and electric cars are all ubiquitous now, but each rely on ingenious feats of engineering beneath their now mundane exteriors. Prof Hannah Fry reveals the science of everyday tech in this series.
Available now on iPlayer

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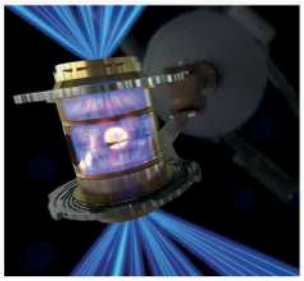

A breakthrough in nuclear fusion could help us develop a limitless source of clean, renewable power.

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Can a big screaming session make you feel happier? All together now, "AAAAAAAARGH!"

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This Valentine's Day, forget flowers, chocolates and tender embraces. In the animal kingdom, romance comes in the form of flesh shredding, sexual cannibalism and parasitism. Mwah.

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EYE OPENER

And away we go...

A few hours after the Artemis 1 mission lifted off from Florida's Kennedy Space Center on 16 November, its payload, the Orion spacecraft, snapped this selfie as it left Earth to begin its journey to the Moon. Orion's maiden voyage – a significant step in NASA's endeavour to return to the Moon – was billed as an uncrewed test flight, but there were a few passengers along for the 25-day, 2.1 million kilometre ride.

In the pilot's seat was Commander Moonikin Campos, a life-sized mannequin. Campos was wearing the Orion Crew Survival Suit to see how well it protects astronauts during launch and re-entry. Travelling with Campos were Helga and Zohar, two female-shaped plastic torsos equipped with 5,600 sensors to detect the radiation that future astronauts will be exposed to. Female torsos were chosen because more women are becoming astronauts and, if all goes according to plan with the Orion test flights, the Artemis programme intends to land the first female astronaut on the Moon, possibly by 2025.

NASA/ESA/CSA

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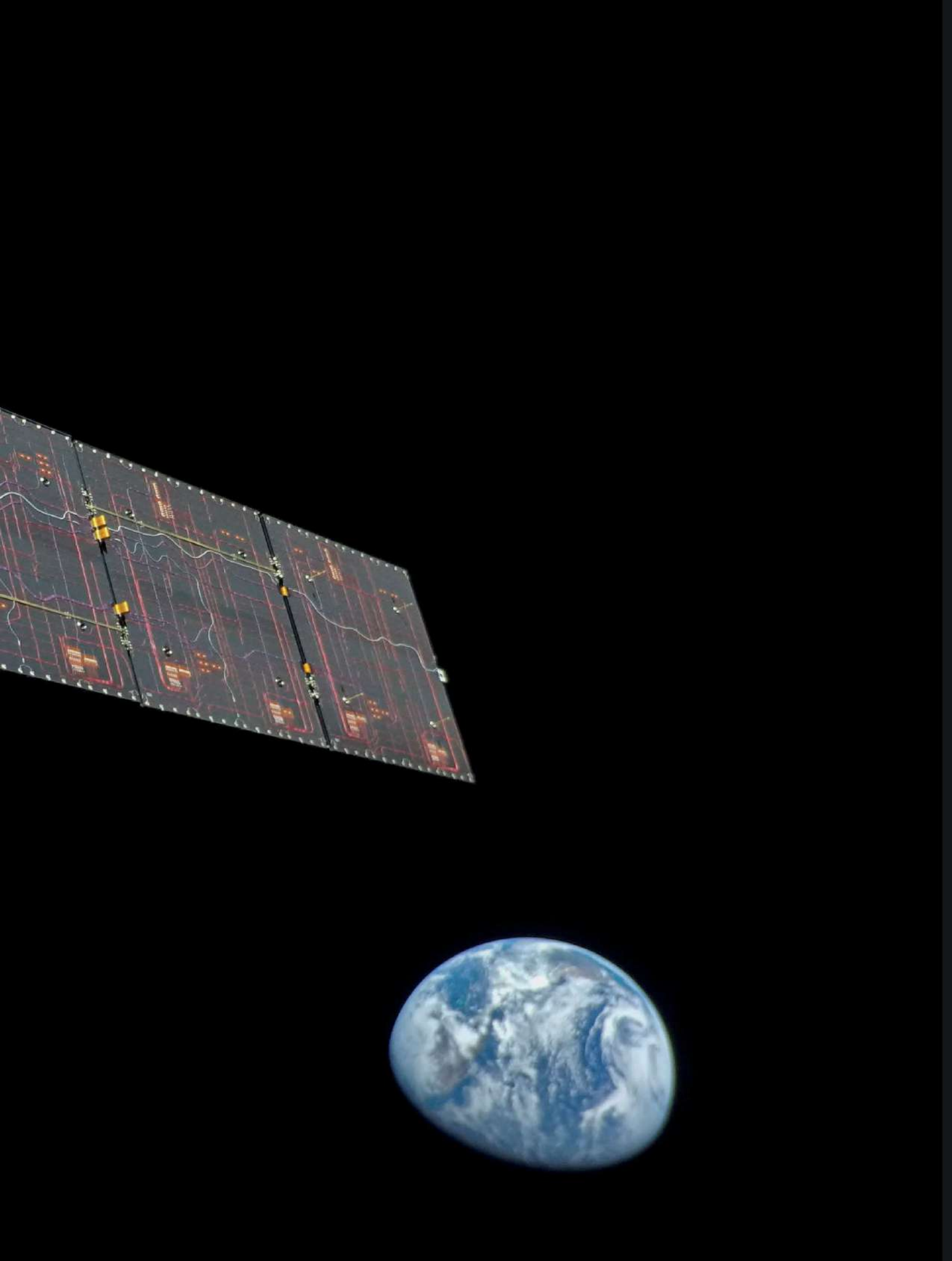

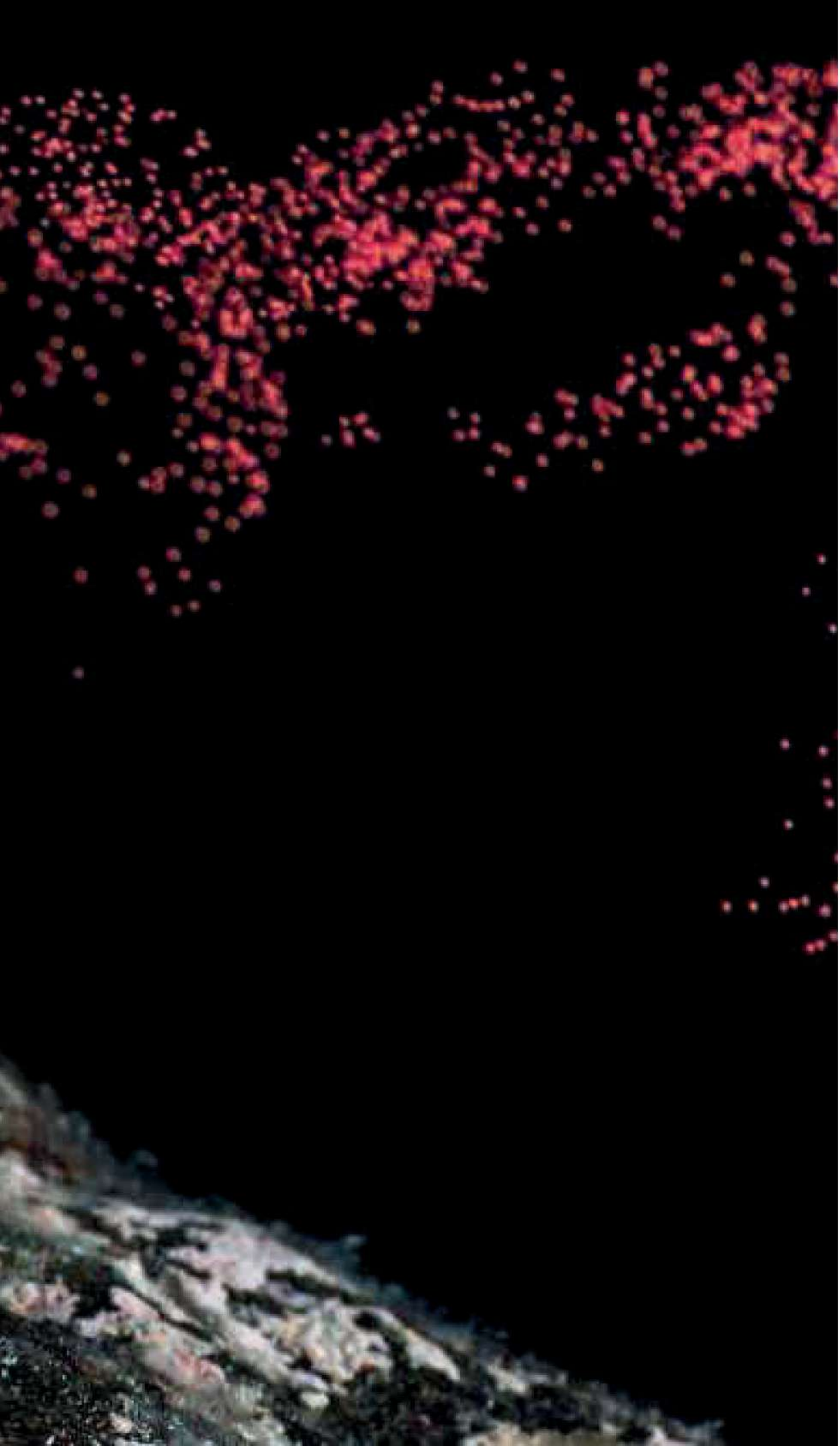

EYE OPENER

Streaming spawn

HOKKAIDO, JAPAN

Limpets are fascinating creatures, especially when it comes to reproduction. The female spawning here is believed to be a *Lottia emydia*. Little is known about the species and it's rare to see them releasing eggs like this.

What's curious about this one is the way it's lifted its shell, like a parasol. "It puts the individual at serious risk of being dislodged by water movement or predation," says Dr Louise Firth, associate professor of marine ecology at the University of Plymouth. "That said, in Hong Kong, when limpets are too hot when the tide is out, they will lift their shells to cool down, a behaviour called 'mushrooming.'"

In some limpet species, spawning is triggered by environmental factors, like a drop in temperature and the onset of winter storms. "It's why limpets are considered indicators of climate change in northwest Europe," says Firth. "Their reproductive responses can tell us a lot about what's happening with climate change."

TONY WU/NATUREPL.COM

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CONVERSATION

YOUR OPINIONS ON SCIENCE, TECHNOLOGY AND *BBC SCIENCE FOCUS*

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LETTER OF THE MONTH

Fiery issue

I was interested by Prof Dann Mitchell's article on wildfires, (Summer, p86) which brought back memories of the Ash Wednesday fires in 1983 in southeast Australia.

The aftermath of Australia's bushfires in 1983

I was based in London, but worked for the insurance companies that paid for the damage. After the events, we were sent videos and reports detailing what happened and why. Due to the extreme winds, high temperatures and extended drought, the fires spread with frightening speed. In one location, the fire was approaching a four-lane highway, so the fire services back-burned an area along either side of the road to remove any fuel. They set up with water and waited. The fire approached, travelling over 25mph (40km/h), jumped straight across the road and the fire break, continuing on past the fire services.

In some areas, there were many eucalyptus trees, which store oil in their leaves. When the flames reached the trees, the oil ignited instantly and sent out a jet of flame (just like a wartime flamethrower). From the top of the trees, these jets jumped 80 metres or more ahead of the fire front and pushed the fire forward even faster. The intensity of the firestorm was so extreme that the fire was running out of oxygen and sucked in air from the surrounding area to keep itself alive. This created a vortex of such force that air from in front of the fire was being dragged in with such ferocity that some buildings imploded by the pressure vacuum and were sucked into the fire. The London Insurance Market was sent videos of these events, and they were unquestionably the most frightening videos I have ever seen.

Colin Holbrook, via email

WRITE IN AND WIN!

The writer of next issue's *Letter Of The Month* wins a **Vango Radiate Grande DLX chair from Outdoor World Direct**. The graphene heating element inside the chair offers four different heat settings, keeping campers and stargazers warm, even in winter. The chair can easily be powered using a regular power bank, making it ideal to use on the go. It is also extra wide, so is perfect for larger people or those who want a little more space. **outdoorworlddirect.co.uk**

Pong-playing mini brains

I have just read with interest about how scientists have taught brain cells to play *Pong* (November, p14). The potential uses for this technology to test drugs and conduct research into neurodegenerative diseases is most heartening. As someone who has a close relative who suffers from Huntington's disease, any help in combatting this, and other such horrible diseases that rob people of their own selves, will be very welcome.

Clare Barber, via email

More climate change coverage, please

While you have excellent coverage of many aspects of science, there seems to be far more on space and astronomy than on climate change. While moonshots and other space exploration can be exciting and involve leading-edge technology, climate change presents an existential threat. One of the problems in addressing climate change is how little people (especially politicians) understand about its causes and the various technologies being proposed to mitigate it. By featuring more of the issues – and especially by covering the technical details and pros and cons of the various technologies being proposed – you could play a real role in helping us save the planet.

David Scott, via email

Don't forget climate change, says David Scott

"IT'S IMPOSSIBLE TO ANTICIPATE WHAT THE CHATBOT MIGHT SAY IN EVERY GIVEN SITUATION, MAKING IT A LIABILITY HAZARD FOR A LOT OF APPLICATIONS"

DR KATE DARLING, P30

Can algorithms really cut crime, ponders Bob Sanner

SYDNEY DATS/FLICKR/WIKIPEDIA COMMONS, GETTY IMAGES X2

Algorithm bias

In your interview with Prof Ishanu Chattopadhyay of the University of Chicago (Summer, p28), he says he has devised a complex AI algorithm to predict "with 80 to 90 per cent accuracy" where and when murders would take place, without racial bias. This reminds me of the old adage: "I wish I knew where I am going to die because I'd never go near the place."

If we implement his AI, murders will supposedly reduce by 80 per cent in the inner cities... but when we do that, wouldn't this new lack of murders at that location create new historical data? And so, the predictive model is not predictive any longer. If the police want to predict locations of crime, they look at historical data – do we really need AI to do that?

Bob Sanner, via email

Predictions are made in science all the time. Weather predictions, for example, used to be very inaccurate, but with better models we now get it right more often than not. So the fact that we can model and predict a complex system should not be that surprising. Would our actions change the system? Yes, they would and we would need to update our models when they do.

We can track and model predictive performance, and trigger an update when performance dips. Police do use historical data, but they can only tell which places are more prone to crime on average, not when and where the events will occur with quantified uncertainty. To do that, you need AI.

Prof Ishanu Chattopadhyay, University of Chicago

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THE TEAM

EDITORIAL
Editor Daniel Bennett
Managing editor Alice Lipscombe-Southwell
Commissioning editor Jason Goodyer
Digital editor Thomas Ling
Staff writers Alex Hughes, Holly Spanner

ART
Art editor Joe Eden
Picture editor James Cutmore

CONTRIBUTORS
Amy Arthur, Claire Asher, Rob Banino, Hayley Bennett, Peter Bentley, Steve Boswell, Daniel Bright, Steve Brusatte, Stuart Clark, Trevor Cox, Daniel Crespo, Kate Darling, Sam Falconer, Sam Freeman, Helen Glenny, Alice Gregory, Matt Holland, Jules Howard, Christian Jarrett, Stephen Kelly, Pete Lawrence, Katie Mack, Nish Manek, Neil McKim, Radha Modgil, Stephanie Organ, Emily Peck, Helen Pilcher, Helen Scales, Kyle Smart, Ian Taylor, Valentin Tkach, Magic Torch.

ADVERTISING & MARKETING
Business development manager David D'Souza
Newstrade manager Rob Brock
Subscriptions director Jacky Perales-Morris
Direct marketing manager Kellie Lane

MOBILE
Head of apps and digital edition marketing Mark Summerton

INSERTS
Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION
Director of licensing and syndication Tim Hudson
International partners manager Anna Brown

PRODUCTION
Production director Sarah Powell
Production coordinator Lauren Morris
Ad services manager Paul Thornton
Ad designer Julia Young

PUBLISHING
Publisher Andrew Davies
Group managing director Andy Marshall
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BBC STUDIOS, UK PUBLISHING
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This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And for so many survivors the road to recovery is still long and desperately lonely. If you or someone you love has been affected by stroke – you'll know just what that means.

But it doesn't have to be like this. You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries and every single stroke survivor has the best care, rehabilitation and support network possible, to help them rebuild their lives.

Will you make that promise to generations to come? Please, leave a gift in your Will to the Stroke Association.

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Rebuilding lives after stroke

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Stroke Association

DISCOVERIES

"This is a huge boost for all fusion efforts and will raise ambitions across the board"
Dr Valerie Jamieson **p15**

ENERGY

SMASHING NEWS

Breakthrough fusion experiment has generated more energy than it put in for the first time **p14**

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Heart attack on a chip could unlock new cardiac treatments **p16**

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WATCH OUT, CANCER!

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Tiny microstructures on the pads of polar bears give them excellent grip in slippery conditions

PHYSICS

NUCLEAR FUSION BREAKTHROUGH BRINGS UNLIMITED CLEAN ENERGY ONE STEP CLOSER

For the first time, the atom-smashing technique has been successfully used to generate more energy than researchers put in

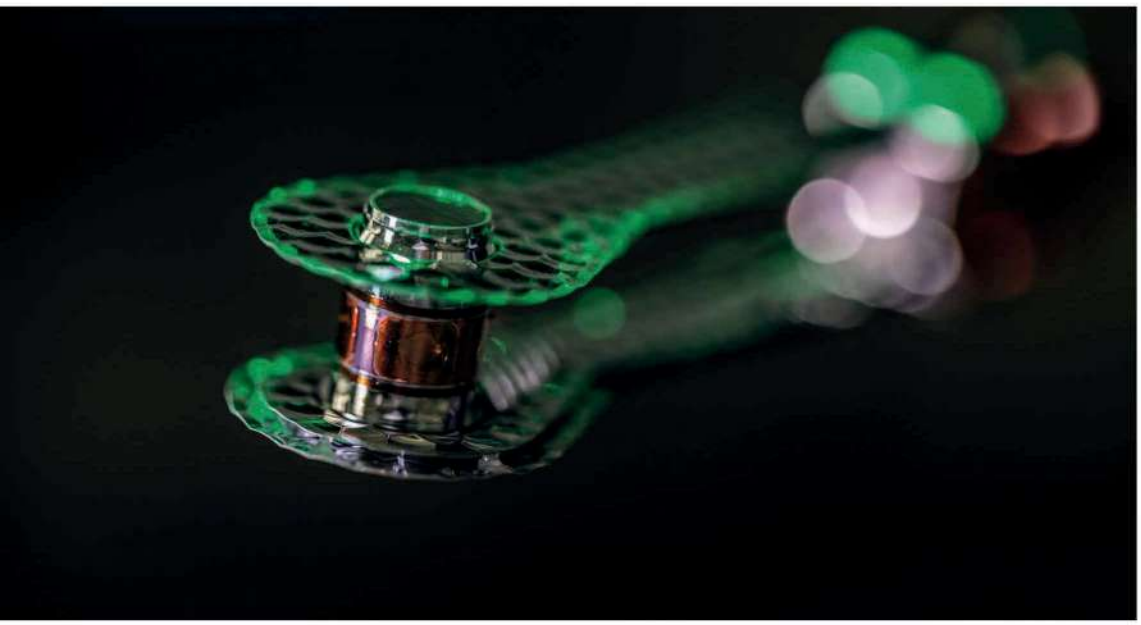
ABOVE The target chamber of Lawrence Livermore National Laboratory, where scientists created fusion ignition for the first time

Scientists at the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) in the US have successfully generated a net gain in energy via a nuclear fusion reaction for the first time in history – a phenomenon known as 'ignition'.

The breakthrough comes after decades of research efforts by scientists all around the globe. It represents a significant step towards a clean, reliable energy source that could one day end humanity's dependence on fossil fuels.

"The pursuit of fusion ignition in the laboratory is one of the most significant scientific challenges ever tackled by humanity, and achieving it is a triumph of science, engineering, and most of all, people," said Dr Kim Budil, the director of the LLNL, speaking at a press conference on 13 December.

"Crossing this threshold is the vision that has driven 60 years of dedicated pursuit – a continual process of learning, building, expanding knowledge and capability, and then finding ways to overcome the new challenges



"Crossing this threshold is the vision that has driven 60 years of dedicated pursuit"

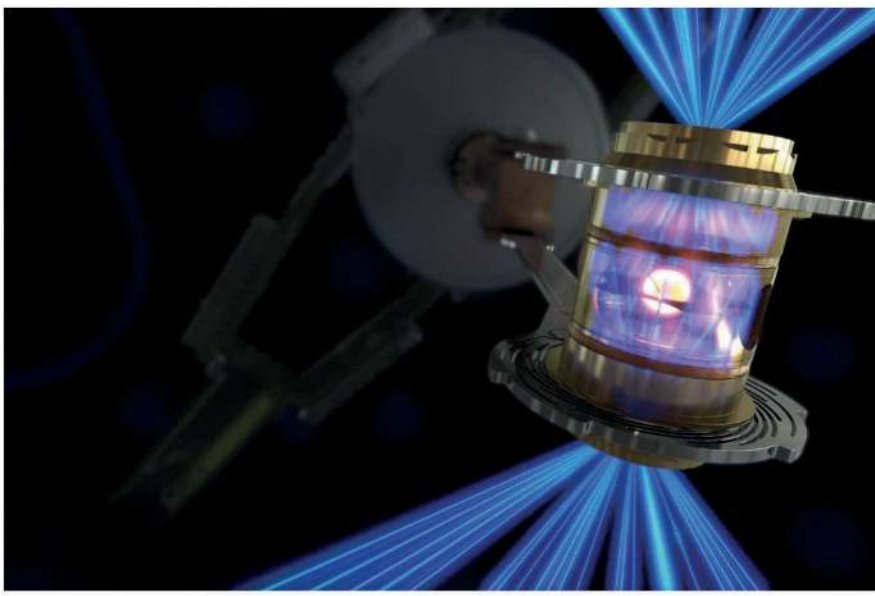
that emerged. These are the problems that the US National Laboratories were created to solve."

Fusion reactions occur when the nuclei of atoms are forced together by extreme pressures or temperatures. When this force is strong enough to overcome the electrostatic force that repels them, the nuclei are pulled together by the strong nuclear force – one of the forces described by the Standard Model of particle physics. This leads to them being fused together and creating a new, heavier nuclei, with energy produced in the process.

In the case of the NIF, which is the world's largest and most powerful fusion reactor, the nuclei used were two isotopes of hydrogen: deuterium, which contains one neutron and one proton; and tritium, which contains two neutrons and one proton. These combine to form helium nuclei. As the mass of the helium nuclei is slightly less than the mass of two hydrogen nuclei, this extra mass is released as energy.

The reactor achieves this by shooting nearly 200 energetic lasers into a hollow cylinder called a hohlraum. The hohlraum contains a small spherical capsule of the hydrogen isotopes, the 'fuel' for the experiment. This generates an aura of X-rays that triggers an implosion that moves at more than 400km/s. This creates huge pressures and temperatures that cause the hydrogen isotopes to fuse.

In their latest run, the researchers put around 2.05MJ of energy in and got 3.15MJ out – a net gain within the system. However, they had to put 300MJ of energy into the lasers to generate the initial pulse, with only 2.05MJ actually making it to the target – a figure that is still considerably lower than what would be needed to consistently generate electricity. This means that, although the results are promising, we are still a way off from seeing the first nuclear fusion power plant. Still, this represents a significant improvement on the previous record set by the NIF team in August 2021, when they got 1.3MJ out of an input of 2MJ.



TOP The small, cylindrical hohlraum, into which the hydrogen fuel capsule is placed

ABOVE Within the fusion experiment, lasers are fired at the hohlraum, which generates the X-rays that kickstart the fusion process

"What the NIF result shows is that inertial fusion can release more energy from fusion than goes into heating the fuel. This is a huge boost for all fusion efforts and will raise ambitions across the board," said Dr Valerie Jamieson, fusion cluster technology manager at UK Atomic Energy Authority, who was not involved in the research.

"Bear in mind that NIF is an experiment, not a power plant, and its specific approach using 192 high power lasers isn't commercially viable. That said, this result is important to commercial fusion efforts that are working towards a power plant. There are still challenges to overcome, but we have never been closer to fusion."

DAMIEN JEMISON, LLNL X2

MEDICINE

'HEART ATTACK ON A CHIP' COULD UNLOCK NEW CARDIAC TREATMENTS

The new device allows researchers to observe changes to heart tissue in real time

Patients recovering from a cardiac event could one day have more effective treatments, thanks to a new medical device dubbed a 'heart attack on a chip'.

The device, designed by scientists from the University of Southern California, consists of a 2 x 2cm microfluidic framework made from a rubber-like polymer called polydimethylsiloxane, with channels running through it on either side that gas can flow through. Within it is a microlayer of rodent heart cells that are grown on a scaffold of proteins patterned to mirror the structure of heart tissue.

Heart attacks occur when fat, cholesterol and other substances in the coronary arteries severely reduce the flow of oxygen-rich blood to part of the heart.

In the device, this effect can be mimicked by passing gas with or without oxygen through the microfluid in the channels.

"Our device replicates some key features of a heart attack in a simple and easy-to-use system," said Megan McCain, an associate professor of biomedical engineering, stem cell biology and regenerative medicine, who developed the device.

"This enables us to understand more clearly how the heart is changing after an attack. We can then develop and test drugs that will be most effective for limiting the degradation of heart tissue that occurs after a heart attack."

After recovering from a heart attack, patients' heart cells are unable to regenerate like other muscle cells. Heart tissue may also suffer from scarring, which leads to a reduction in the amount of blood the heart can pump around the body. Researchers do not currently understand how this happens.

The biomedical device will allow researchers to observe these changes in real time and study changes in heart rhythm and contraction strength in the laboratory.

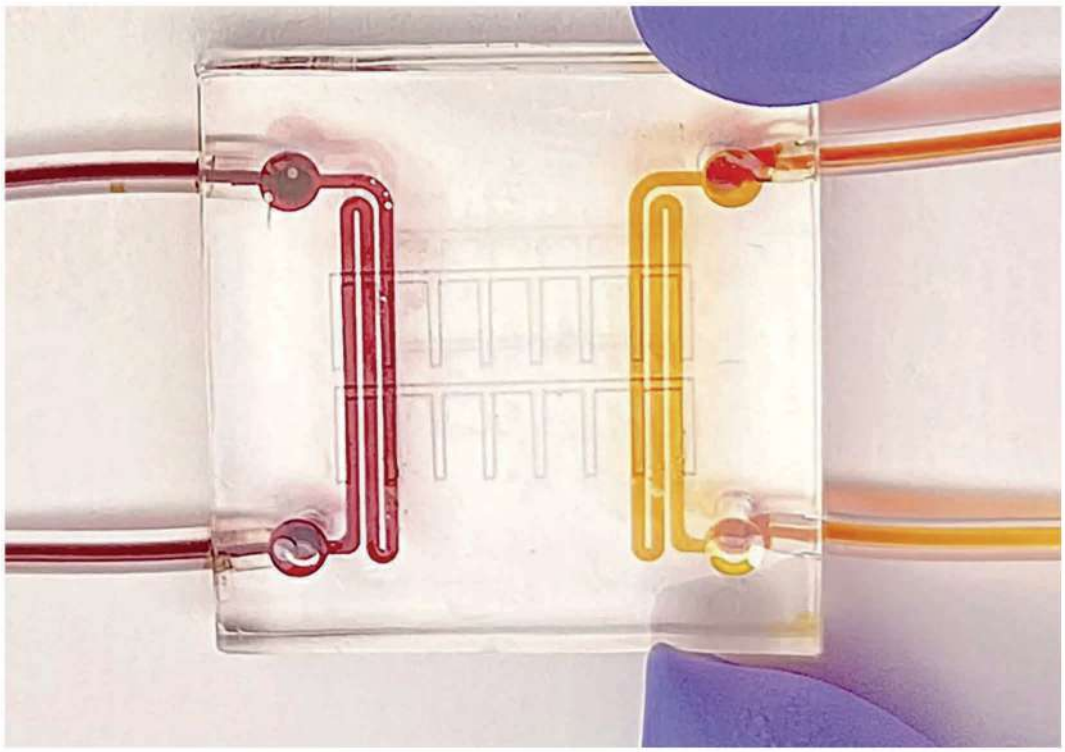
"It is actually very exciting and rewarding to envision our device having a positive impact on patients' lives in the near future, especially for heart attacks, which are extremely prevalent," said McCain.

HEART ATTACK FACTS

7.6m people in the UK are currently living with heart disease

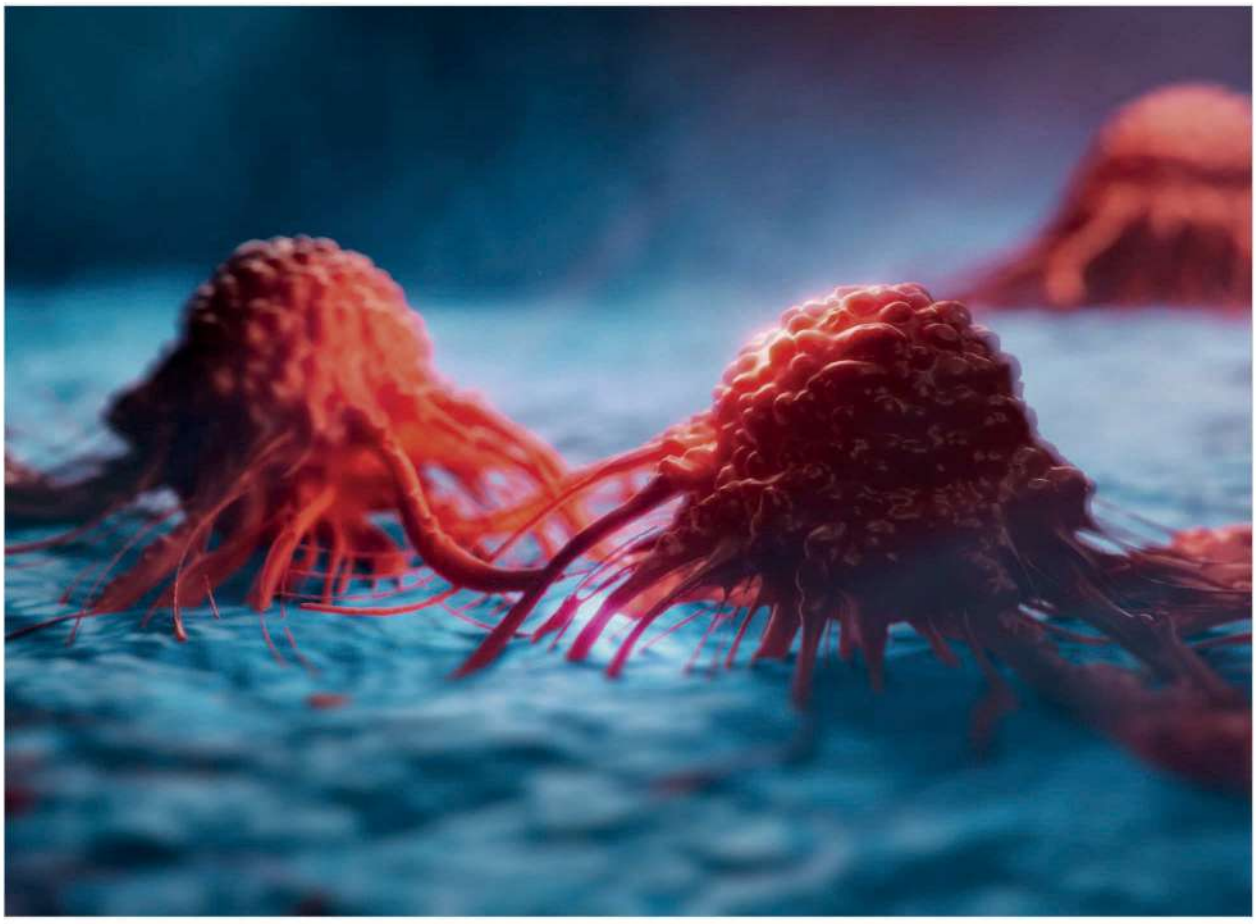
Every three minutes, someone in the UK dies from a heart or circulatory disease

Every five minutes, someone is admitted to hospital due to a stroke



BELOW The 'heart attack on a chip', could one day be used to test personalised heart drugs

MEGAN REXIUS, GETTY IMAGES



LEFT The new test can detect multiple cancers that are not currently being screened for

CANCER

GROUND-BREAKING SCREENING TEST CAN CATCH 14 CANCERS IN THE EARLY STAGES

The new test, which measures metabolic sugars found in the blood and urine, could boost cancer survival rates

Catching cancer in its early stages is one of the most effective ways that doctors have of improving patients' survival rates. But this can be difficult, as many of the screening tests in current use are type-specific. This means that patients need to take separate tests to check for each type of cancer of which they are at risk.

Projects are currently underway to develop multi-cancer early detection (MCED) tests, but most of these focus on screening for DNA shed from tumours and have a limited ability to detect cancerous cells during the earliest stages of the disease. Now, researchers from Chalmers University of Technology, Sweden, have developed a simple MCED blood or urine test using machine-learning algorithms that can accurately detect 14 different Stage 1 cancers. Stage 1 cancers are those which are small, and haven't yet spread. Instead of searching for DNA from tumours, the test looks for particular changes in glycosaminoglycans – a type of metabolic sugar – that are known to be caused by cancerous cells.

In a study involving more than 1,250 participants, both healthy and previously diagnosed with cancer, the researchers found that the test could detect multiple cancers, including kidney and brain tumours. It was also twice as effective as DNA-based MCED tests in detecting Stage 1 cancers in asymptomatic people.

"This study gives us hope that one day society will be able to create screening programmes that can detect all cancer types early," said study author Francesco Gatto, a visiting researcher at Chalmers.

"The groundbreaking method makes it possible to find cancer types that are not screened for today and cannot be found with DNA-based MCED tests, such as brain tumours and kidney cancer.

"The fact that the method is comparatively simple means that the cost will be low, enabling more people to have access to the test."

ENGINEERING

SNOW TYRES INSPIRED BY POLAR BEAR PAWS COULD PROVIDE BETTER GRIP

Tiny structures on the bears' paw pads produce the traction that allows them to move freely on ice and snow

An interdisciplinary group of researchers based at the University of Akron in Ohio has come up with a way to make it easier to drive in the snow: by designing tyres based on polar bear paws.

"We had an ongoing project for many years focused on ice," said Prof Ali Dhinojwala, who took part in the research. "We were looking at the friction of materials [because] our national partners need to develop tyres with a strong grip on the road in ice and snow conditions."

The team turned to nature for inspiration, on the assumption that evolution may have already come up with a solution to the problem that could be replicated with technology (an approach known as biomimicry). The obvious place to look was polar bears – specifically the tiny bumps, known as papillae, on the surface of their paw pads – to find out what effect they have on the animals' ability to move quickly across icy and snowy terrain.

To do this, the team gathered samples of polar bear paw pads, as well as samples from brown bears and American black bears (two species closely related to polar bears) and sun bears (a distantly related species, typically found in Asia).

"The quietness of the lab during COVID gave me the opportunity to connect with a variety of scientists and environmentalists across the country," said Dr Nathaniel Orndorf, a former PhD student involved in the research, who now works for tyre manufacturer Bridgestone. "I reached out to museums, taxidermists and many others to collect and view actual samples and replicas of bear paw pads."

The team imaged the samples using a scanning electron microscope, produced 3D-printed replicas and then tested them in snow in the lab. They found that the papillae on the polar bear paw pads were taller, which gave them better traction on the snow, even though polar bears have smaller pads compared to other bears.

The team now wants to investigate other factors that may have an effect, such as the patterning and profile of the papillae.

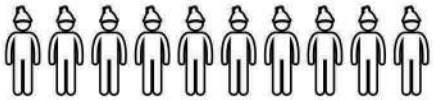
"If you look at snow tyres you'll see that they do have some deeper treads, but this research could also show various ways to design them that could have a larger impact," said Dhinojwala.

GETTY IMAGES, SCIENCE PHOTO LIBRARY

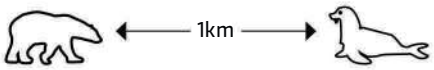
ABOVE Polar bear paw pads, although smaller than those of other large bears, offer greater grip on low-friction surfaces such as ice and snow

POLAR BEAR FACTS

Polar bears have jet black skin and their fur is actually transparent. They only appear white due the light reflecting off their fur.



Male bears are twice the size of females and can weigh up to 800kg, nearly 10 times the weight of an average UK male.



Polar bears have an incredible sense of smell and can detect the scent of a seal up to a kilometre away.

HEALTH

COVID: THE CAUSE OF LONG-TERM SMELL LOSS MAY HAVE BEEN FOUND

A similar mechanism could also be responsible for other symptoms of long COVID, such as brain fog, shortness of breath and fatigue

The loss of your sense of smell has been one of the tell-tale signs that you've been infected with coronavirus since the pandemic struck in early 2020. But while most COVID patients recover their sense of smell within a few weeks, for some it persists for months or even years.

Now, researchers at Duke University Medical Center in the US think they may have figured out why: the infection causes an ongoing immune assault on nerve cells within the nose.

"One of the first symptoms that has typically been associated with COVID-19 infection is loss of smell," said co-researcher Bradley Goldstein, an associate professor at Duke.

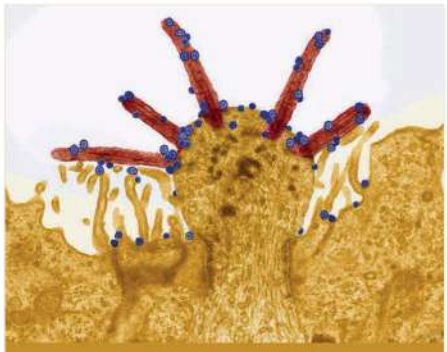
"Fortunately, many people who have an altered sense of smell during the acute phase of viral infection will recover smell within the next one to two weeks, but some do not. We need to better understand why this subset of people will go on to have persistent smell loss for months to years after being infected with SARS-CoV-2."

The researchers analysed samples of nasal tissue taken during the biopsies of 24 patients, nine of whom were suffering from long-term smell loss following infection with the coronavirus.

They found that T-cells, white blood cells that play a key role in the immune system, were triggering an inflammatory response in the olfactory epithelium, the small area at the top of the nasal cavity where nerve cells that process smells are located. The inflammation was continuing, despite the absence of detectable SARS-CoV-2 virus.

"The findings are striking," Goldstein said. "It's almost resembling a sort of autoimmune-like process in the nose. We're hopeful that modulating the abnormal immune response or repair processes within the nose of these patients could help to at least partially restore a sense of smell."

The finding also suggests that a similar mechanism could be responsible for other symptoms of long COVID, such as brain fog, shortness of breath and fatigue, the researchers say.



What is long COVID?

The majority of patients suffering from COVID-19 feel better in a few days and are completely free of symptoms within 12 weeks. For some, however, symptoms can last for months or even years – this is a condition known as long COVID.

Long COVID is an emerging condition and is still being studied, but patients can display a myriad of symptoms from fatigue to depression and tinnitus.

The Office of National Statistics currently estimates that 2.1 million people in the UK are living with long COVID, with the condition being most common among females, people living in deprived areas and those with another activity-limiting health condition.

HEALTH

FERMENTED FOODS COULD CONTAIN A CURE FOR BAD BREATH

Probiotic bacteria found in yoghurt, kimchi and sourdough bread have been identified as a temporary remedy for halitosis

ABOVE Bacteria in fermented foods, such as kimchi, may help keep bad breath at bay

Bad breath is the bane of many people's lives, but a cure for it could be found in fermented foods like yoghurt, sourdough bread or kimchi.

A new meta-analysis published in the journal *BMJ Open* has linked four probiotic bacteria to a reduction in bad breath (halitosis). The four bacteria – *Lactobacillus salivarius*, *Lactobacillus reuteri*, *Streptococcus salivarius* and *Weissella cibaria* – can be found in common foods, but the study looked at their effectiveness when taken in the form of supplements.

Bad breath is normally caused by volatile sulphuric compounds, produced by bacteria in the mouth mixing with food debris stuck on the tongue or between teeth. The usual advice for dealing with halitosis involves brushing and flossing your teeth regularly, tongue scraping, and using various types of breath freshener, such as mouthwash, spray or chewing gum. But consuming probiotic bacteria could also help.

To address the four bacteria's effectiveness at freshening breath, the scientists looked through research databases for relevant clinical trials published up to February 2021. In the studies they selected for analysis (which included a total of 278 people aged between 19 and 70), bad breath was defined by levels of volatile sulphuric compounds detected in the mouth and the OLP score – a measure of breath odour at various distances.

The data from these studies showed a significant reduction in the OLP scores of people given probiotics, compared to the control groups. Similar reductions were found in the levels of volatile sulphuric compounds being detected, although these results were relatively short-lived with no noticeable difference after four weeks.

While there was a reduction in breath odour, there was no significant change in plaque or debris on the tongue, two common factors in bad breath. This suggests that the probiotics may inhibit the decomposition of amino acids in the mouth, curbing the production of smelly by-products.

While the study offers real-world methods for dealing with bad breath, the researchers urge caution.

"This systematic review and meta-analysis indicates that *Lactobacillus salivarius*, *Lactobacillus reuteri*, *Streptococcus salivarius* and *Weissella cibaria* may ease halitosis by reducing the [volatile sulphuric compound] concentration levels in the short term, but there is no significant effect on the major causes of halitosis, such as plaque and tongue coating," they wrote.

"More high-quality randomised clinical trials are required in the future to verify the results and to provide evidence for the efficacy of probiotics in the management of halitosis," they added.

GETTY IMAGES, LOREN DAVIS

ARCHAEOLOGY

STONE WEAPONS MAY LINK THE ICE AGE PEOPLES OF NORTH AMERICA AND NORTHEAST ASIA

The discovery of North America's oldest-known stone dart tips is shedding new light on ancient societies

A selection of stone 'projectile points', which are believed to have been used as dart tips, have been found to be 3,000 years older than any similar examples discovered in North America. The remarkable discovery by archaeologists at Oregon State University (OSU), who have been carbon-dating the razor-sharp artefacts, will help to fill in gaps in the history of how early humans crafted and used stone weapons.

Loren Davis, an archaeologist at OSU and head of the group that found the projectile points, said that the discovery of these artefacts is important, not just because of their age, but because of their similarity to items found in Hokkaido, Japan, dating from 16,000 to 20,000 years ago. Indeed, the presence of these items in Cooper's Ferry, in present-day Idaho, lends more weight to the theory that there may be early genetic and cultural connections between the Ice Age peoples of northeast Asia and North America.

The projectile points (some intact, some fragmentary) range from about 1.2cm to 5cm in length and have been shown to date from 15,700 years ago, which pre-dates fluted stone points previously found in the US. They also pre-date any similar weapons found at the same Cooper's Ferry excavation site, alongside the Salmon River, by 2,300 years.

"From a scientific point of view, these discoveries add important details about what the archaeological record of the earliest peoples of the Americas looks like," said Davis. "It's one thing to say, 'we think that people were here in the Americas 16,000 years ago.' But it's another thing to measure it by finding well-made artefacts they left behind."

The Cooper's Ferry site, where the projectile points were found, is currently owned by the US government's Federal Bureau of Land Management. But it used to be a village known as Nipéhe, located within the territory of the Nez Percé, a tribe of indigenous people that lived in the Pacific Northwest.

"The earliest peoples of North America possessed cultural knowledge that they used to survive and thrive over time. Some of this knowledge can be seen in the way people made stone tools, such as the projectile points found at the Cooper's Ferry site," said Davis.

"By comparing these projectile points with those of other sites of the same age and older, researchers can then get a sense of the social networks where this technological knowledge was shared between peoples."

The stone projectile points, which were uncovered in digs taking place during summers between 2012-2017, are characterised by two distinct ends – one sharpened and one stemmed – as well as a symmetrical bevelled shape (with sloping rather than squared edges).

BELOW The ancient projectile points were found at the Cooper's Ferry archaeological site in Idaho, USA

PRIMER

BIODIVERSITY

What is the current state of the Earth's flora and fauna, and what can we do to protect it?

GETTY IMAGES, ZSL LONDON

In December 2022, government representatives and other official bodies from around the world met in Montreal, Canada, for COP15: The UN Biodiversity Conference. Among the many things discussed was the so-called '30 by 30' target – the pledge to conserve 30 per cent of the planet's terrestrial and marine habitat by 2030.

We spoke to Dr Andrew Terry, director of conservation and policy at the Zoological Society of London (ZSL), about the significance of the target, the current state of Earth's biodiversity and what we can do to reverse the already devastating losses.

WHAT IS THE DEFINITION OF BIODIVERSITY?

Biodiversity speaks to the range of the variety of life. We think about that right from the genetic level all the way up to whole ecosystems. We tend to only think about the different animals, plants and fungi that make up life, but biodiversity is the full variety of life on Earth. Unfortunately, biodiversity is a term that doesn't resonate very well with people. As a technical term it captures something, but we're really talking about nature. And nature underpins the ability of humanity to persist. We depend on it for our health, our wellbeing, the ability of our economies to function. Unfortunately, we've flipped that on its head and we've put our economies at the top and nature at the bottom. Ultimately, that is the root cause of all our problems.

WHAT'S THE CURRENT STATE OF BIODIVERSITY AROUND THE WORLD?

It's declining massively. Every indicator you look at – whether it's the Living Planet Index, which is one that ZSL produces that looks at the state of wildlife populations worldwide, or whether you look at the health of ecosystems or the health of genetic variation – they're all declining. Every single indicator shows us that biodiversity is declining and this has major knock-on consequences for us.

WHAT'S CAUSING BIODIVERSITY LOSS?

Principally, it's habitat use and habitat loss. We're changing natural areas for human use, by turning primary forest into agriculture, highways or mines, for example. It's also direct overexploitation of species through fishing and harvesting practices, or the way in which we clear forests for timber. And then we've got other drivers of change, such as invasive species. As we've moved around the world and become increasingly globalised, we've transferred species into places they shouldn't be.

And then, obviously, climate change comes along. Historically, climate change hasn't been a major driver of change, but we're going to see it come to dominate over the years.

WHAT IS THE '30 BY 30' TARGET? IS IT MORE THAN JUST A CATCHY NAME?

Yes, 30 by 30 is very catchy. I think a number of people really wanted it to be like the 1.5°C global-warming target, but for nature. It refers to wanting to see 30 per cent of terrestrial and ocean systems protected by 2030. So at a very simplistic level, that's what the target is, but there's a lot of detail and nuance that's hidden within that simplicity.

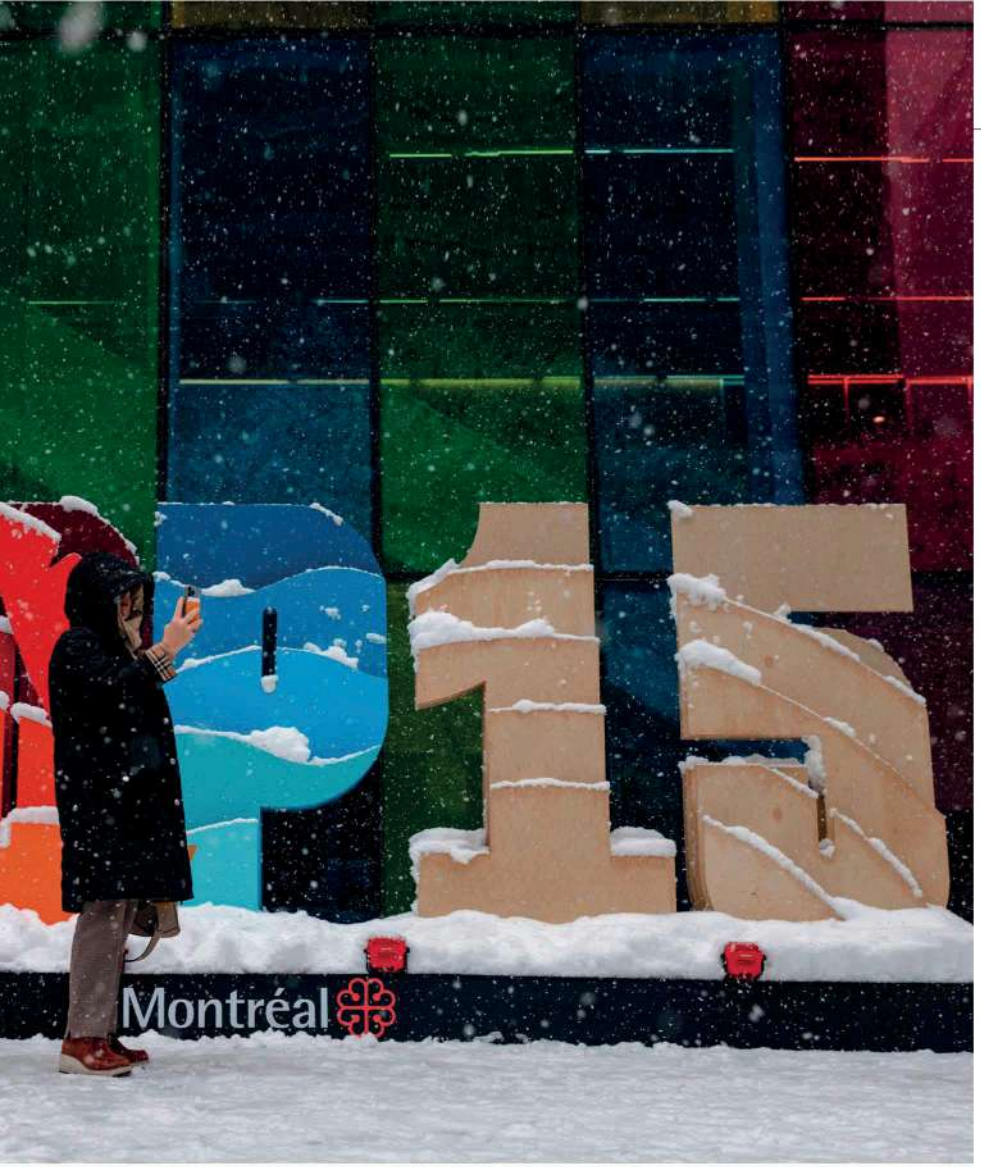
HAS THE TARGET BEEN WELL RECEIVED?

That depends on who you ask. There are two chief criticisms of it. Number one is that it represents a form of fortress-based conservation [by creating protected areas], which can be seen as being very old school. So depending on how you implement it, it can involve quite negative practices in terms of relationships with local communities.

The second major criticism concerns the question of quantity over quality. So 30 per cent by 2030 is a sort of arbitrary target. We know that many areas, effectively, only exist on paper and that biodiversity has declined even as protected areas have increased. If we only think about designating more areas for protected status, we're going to be missing a big part of the problem.

SO HOW ABOUT SOLUTIONS?

This all comes down to implementation and financing. And again, these were the real sticking points in Montreal. We are going to need to see a significant mobilisation of resources. There's



The '30 by 30' target dominated talks at COP15 in December 2022

"We are seeing nature, sustainability and climate all coming to the fore of people's attention"

a $700bn [£585bn approx] gap in resources available for conservation to get from where we are, to where we think we need to be to solve the problem. Now, countries were very forthcoming with financing at COP and within the new global biodiversity framework, but they were looking at offering $30bn by 2030, not $700bn. So we're going to need to see an increase in both public and private financing.

WHAT NEEDS TO HAPPEN AT GROUND LEVEL?

We have lots of prioritisation tools that tell us where the important areas for different forms of nature are, and we should be focusing on those areas first. We should be looking at how we are integrating communities into the management of those areas and how we can ensure that community lands are adequately supported to protect nature. Because that's where I think that great expansion in numbers is going to come from. It's not going to come from your classic National Park ideas, but from community lands and how they can be supported to protect biodiversity.

To give a tangible example, in the UK we're shifting our subsidy schemes for farming to include nature stewardship as well. So yes, it's for food production, but it's also for protecting nature. How can we protect areas that help us meet multiple targets at the same time?

There's lots of detail about planning and prioritisation and support that's going to have to go into every single country all at the same time. It's quite a job we've got ahead of us.

DO YOU FEEL OPTIMISTIC ABOUT THE FUTURE?

We always talk about a cautious optimism. The presence of the private sector at COP was higher than ever before. Companies have recognised not only the value of looking at nature, but the risks of not looking at nature. That sends a powerful economic signal and we're starting to really see that shift. As the private sector pushes, we will see treasuries and finance ministries starting to take stronger note and that's where the shifts really need to happen.

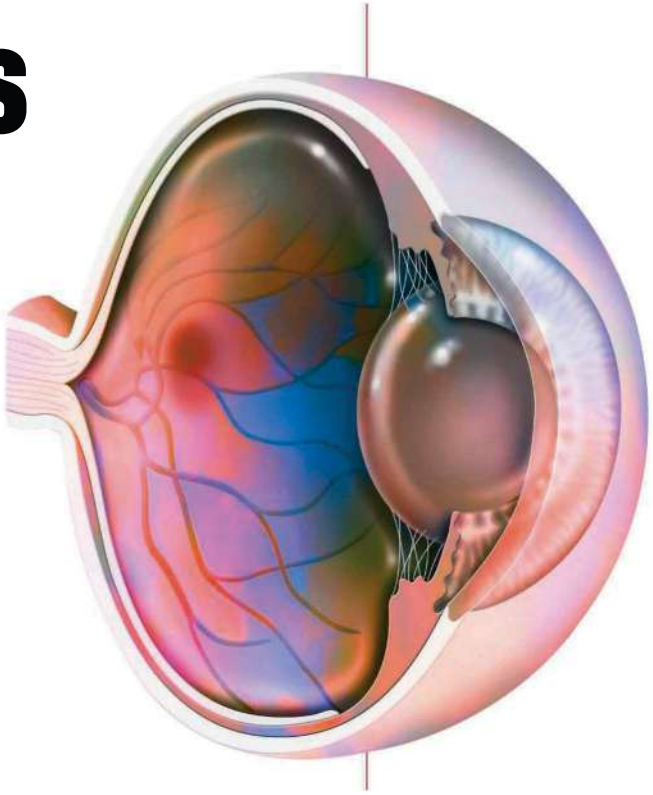
And similarly, I think we are seeing nature, sustainability and climate all coming to the fore of people's attention. From that side, I am really optimistic. My children talk to me about the natural world and know more about their environment than I ever did as a child. The younger generation are getting increasingly critical and asking more questions. So we're seeing action happening. We just need to translate that into the resources that have the impact that will then bend the curve of biodiversity loss in 10 years' time.

I think we are creating the enabling framework, but we need to hold countries to account to actually make the changes and make them now because we don't really have the time.

DR ANDREW TERRY
Andrew is the director of conservation and policy at the Zoological Society of London.

THE FUTURE'S BRIGHT...

As a remedy for all the bad news out there, let us prescribe you a small dose of feel-good science. Each issue, we'll give you a rundown of the latest breakthroughs that aim to solve humanity's biggest problems. From reversing optical degeneration to finding fuel in thin air, here you'll find many reasons to feel hopeful for our future...

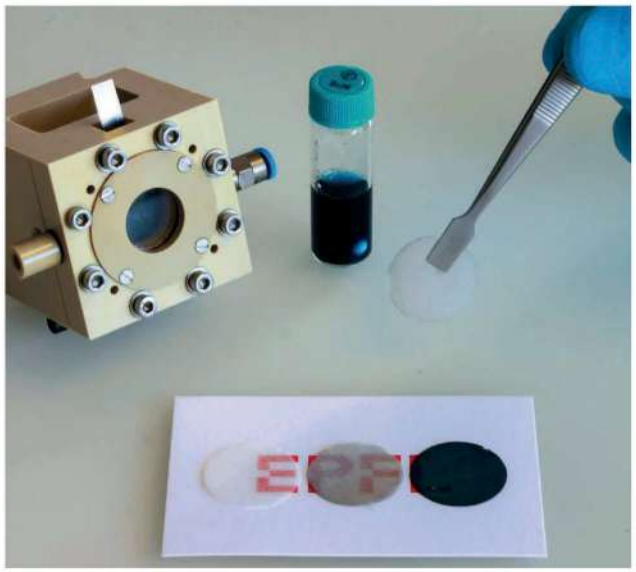


3D PRINTED EYE TISSUE
Researchers at the National Eye Institute in the US have produced retinal tissue using stem cells and 3D bioprinting. The new technique may help scientists model the human eye to better understand – and develop treatments for – diseases and conditions that affect people's vision, such as age-related macular degeneration (AMD). The researchers created tissue found in the outer blood-retina barrier, which is the area AMD is known to start in, by printing stem cells taken from patients into a gel and allowing them to grow over several weeks. They are currently using the tissue to study the progression of AMD and are experimenting with adding additional cell types to model more of the human eye.

YEARS TO GO

25

FUEL FROM THIN AIR
Chemical engineers from Switzerland's École Polytechnique Fédérale de Lausanne have created a prototype device that can produce hydrogen fuel from the water found in air. Inspired by leaves, the device is made from semiconducting materials that harvest energy from sunlight and use it to produce hydrogen gas from water molecules found in the atmosphere. The gas could then, potentially, be converted for use as liquid fuels.



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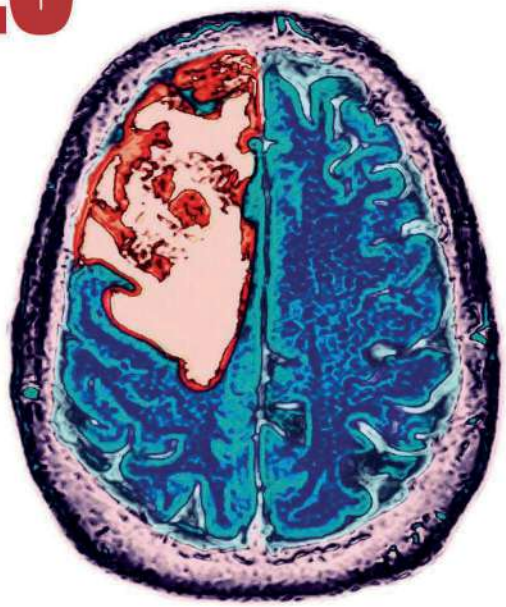
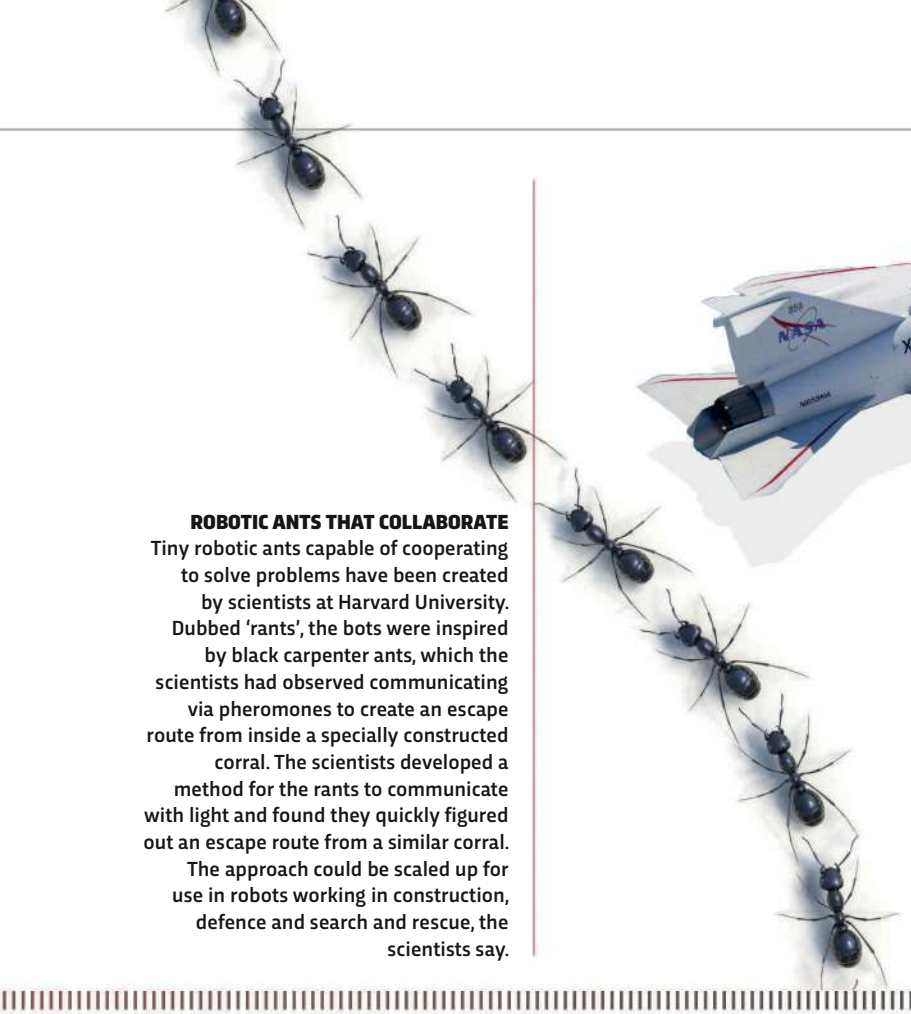


THE CANCER-KILLER INSPIRED BY CANCER
Researchers at Brigham and Women's Hospital have used gene editing techniques to embed a cancer-killing agent in living tumour cells and then deliver them to a target tumour in mice models. The idea behind the treatment is to exploit tumour cells' tendency to seek out fellow tumour cells once they enter a body. The team has so far had success using the technique in mice models that include bone marrow, thymus and liver cells derived from humans. They say that it's likely to be effective in treating a wide range of tumours.

GETTY IMAGES X2, LOCKHEED MARTIN, ALAMY, XIAOXIANG GAO/UC SAN DIEGO, SCIENCE PHOTO LIBRARY, ALAIN HERZOG/EPFL



ROBOTIC ANTS THAT COLLABORATE
Tiny robotic ants capable of cooperating to solve problems have been created by scientists at Harvard University. Dubbed 'rants', the bots were inspired by black carpenter ants, which the scientists had observed communicating via pheromones to create an escape route from inside a specially constructed corral. The scientists developed a method for the rants to communicate with light and found they quickly figured out an escape route from a similar corral. The approach could be scaled up for use in robots working in construction, defence and search and rescue, the scientists say.

BOOM-FREE SUPERSONIC FLIGHT
NASA's X-59 'quiet' supersonic aircraft is set to take to the skies for its first test flight at the Armstrong Flight Research Center later this year. The plane is currently being assembled in a hangar at Lockheed Martin's Skunk Works facility in Palmdale, California. Its fuselage, wings and tail have been specially designed to control the airflow around the plane as it flies, with the ultimate aim of preventing a loud sonic boom from disturbing people on the ground below when it breaks the sound barrier. If the initial test goes to plan, the space agency aims to carry out further test flights over inhabited areas to gauge the public's response to aircraft in 2024.

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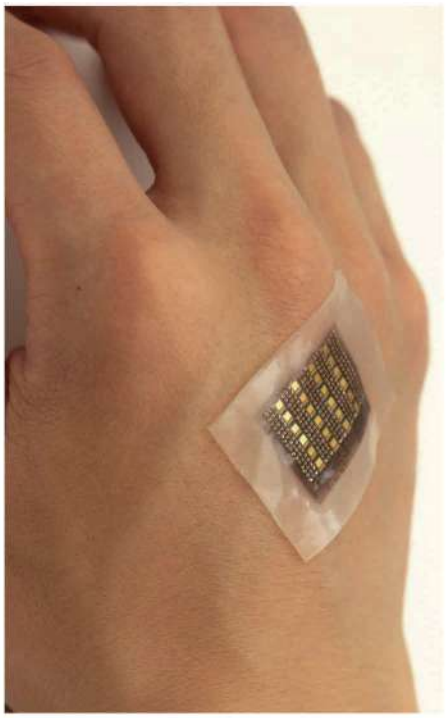


DIAGNOSIS BY SKIN PATCH
Currently, people suffering from life-threatening conditions such as malignant tumours, organ dysfunction or internal bleeding often need to be analysed using bulky equipment such as a magnetic resonance imaging (MRI) scanner. That may soon change, however, as researchers at the University of California, San Diego, have created a more convenient alternative: an electronic patch capable of monitoring molecules within deep tissue. The patch fires laser pulses into tissue and then detects the soundwaves emitted by molecules inside the tissue as they absorb the optical energy. By tuning the laser pulses to different wavelengths, the patch can be used to monitor different molecules to detect the presence of tumours or bleeding. The researchers are currently investigating a range of other clinical applications for the patch.

0

BYE-BYE BRAIN FOG
Along with loss of smell and fatigue, one of the most common symptoms people with long COVID report is problems with their memory and concentration, or 'brain fog'. There are currently no approved treatments for brain fog but, following a small study, a team at Yale found that Guanfacine combined with N-acetylcysteine – both currently available drugs used to treat traumatic brain injury – mitigated or completely eliminated brain fog in 8 out of 12 patients. The team now hopes to carry out a larger, placebo-controlled study.

COMMENT

HOW YOU COULD HELP PROTECT EARTH FROM AN ASTEROID HIT

An asteroid that recently crashed in Ontario highlights the key role of amateurs in tracking asteroids heading for Earth

In the film *Don't Look Up*, a pair of astronomers discover an asteroid on a collision course with Earth. After checking their conclusions, they pass the information to government authorities who order them to remain silent. While word does eventually get out, it's only because the astronomers leak their results, not because the government decides to share the data.

To someone outside astronomy, this might seem plausible. Obviously, the government would want to cover up information so big and dangerous! But those of us working in the field take issue with this plot line. And a meteorite that hit southwest Ontario in November illustrated, in a dramatic way, that a cover-up couldn't be further from the truth when actual Earth-pummelling asteroids are found.

On the night of 18 November, astronomer David Rankin was using a 1.5-metre telescope in Arizona as part of the Catalina Sky Survey, which searches for comets, asteroids and near-Earth objects – anything on a path that might bring it close to Earth. He spotted an object that looked like it might be heading in our direction. Following the usual protocol, he immediately reported the discovery to the Minor Planet Centre (MPC). This is a database of small Solar System objects, maintained by the International Astronomical Union (IAU), that distributes alerts to astronomers about objects of potential interest. The data in the MPC database is not only open to the world, it's automatically updated in real time and posted on the IAU's Near-Earth Object Confirmation Page.

Once Rankin's initial entry was published, it became a free-for-all. Monitoring software from the European Space Agency automatically retrieved the data and within minutes had calculated a likely trajectory, reporting a 20 per cent chance of Earth impact. At the same time, NASA's Scout impact hazard assessment system fired up and arrived at a similar conclusion. That triggered alerts that were sent to astronomers, professional and amateur alike, to fire up their telescopes and either rule out an impact or pinpoint the expected touchdown zone.

Within half an hour of the alert, it became clear that the asteroid, now known as 2022 WJ1, was definitely going to hit, and soon. Some of the key data came from members of the Northeast Kansas Amateur Astronomers' League, a group of volunteers with a self-built observatory on the grounds of a high school in a small town outside of Topeka.

Near-Earth object discovery is one of the areas in which amateur-professional collaboration is most valuable. A government-run research observatory can only monitor a small part of the sky at any given time, limited by field of view, weather conditions and the observatory's position on Earth – sometimes they're looking in the wrong direction. While automated surveys run by professionals do discover most comets and asteroids, any moderate-sized telescope with a good view and a patient observer can pick up a dot moving across the sky, and there is no shortage of dedicated enthusiasts keen to join the effort. The Kansas observers' website boasts that they've discovered over 600 asteroids "and one of the faintest comets discovered by an amateur."

By the time these and other observations proved that 2022 WJ1 was barrelling toward southwestern Ontario, it was also clear that it was, thankfully, unlikely to cause any damage. Calculations based on its brightness suggested it was probably less than a metre in diameter and so could be expected to burn up almost entirely in the atmosphere.

This determination came two hours before impact, so there was ample time to wake up astronomers in the target region and tell them to look up. A few of those bleary-eyed observers captured spectacular images of a bright green meteor trail shooting across the sky, while a webcam in Toronto caught dramatic video of the meteor streaking past the CN Tower. And while the asteroid didn't appear to cause any harm, there's a chance that some fragments of it – maybe even as large as a football – could be recovered from a search of the estimated impact site.

This wasn't the first time an asteroid was discovered before its impact: five other objects have been found since the first in 2008, and some have resulted in successful sample collection. As observatories around the world continue to search the skies, we're sure to continue to find near-Earth objects and see collaboration between major agencies and independent sky-watchers. Public data, automatic alerts and a culture of data-sharing are essential to making that collaboration work, and to ensure we can keep track of whatever the Universe might throw at us next.

DR KATIE MACK
(@AstroKatie)
Katie is a theoretical astrophysicist. She currently holds the position of Hawking Chair in Cosmology and Science Communication at the Perimeter Institute for Theoretical Physics.

"Within half an hour of the alert, it became clear that the asteroid was going to hit"

ILLUSTRATION: MATTHEW HOLLAND

COMMENT

NEW YEAR, SAME YOU?

Don't worry if you've broken your New Year's resolutions already. Try reframing them, and starting again

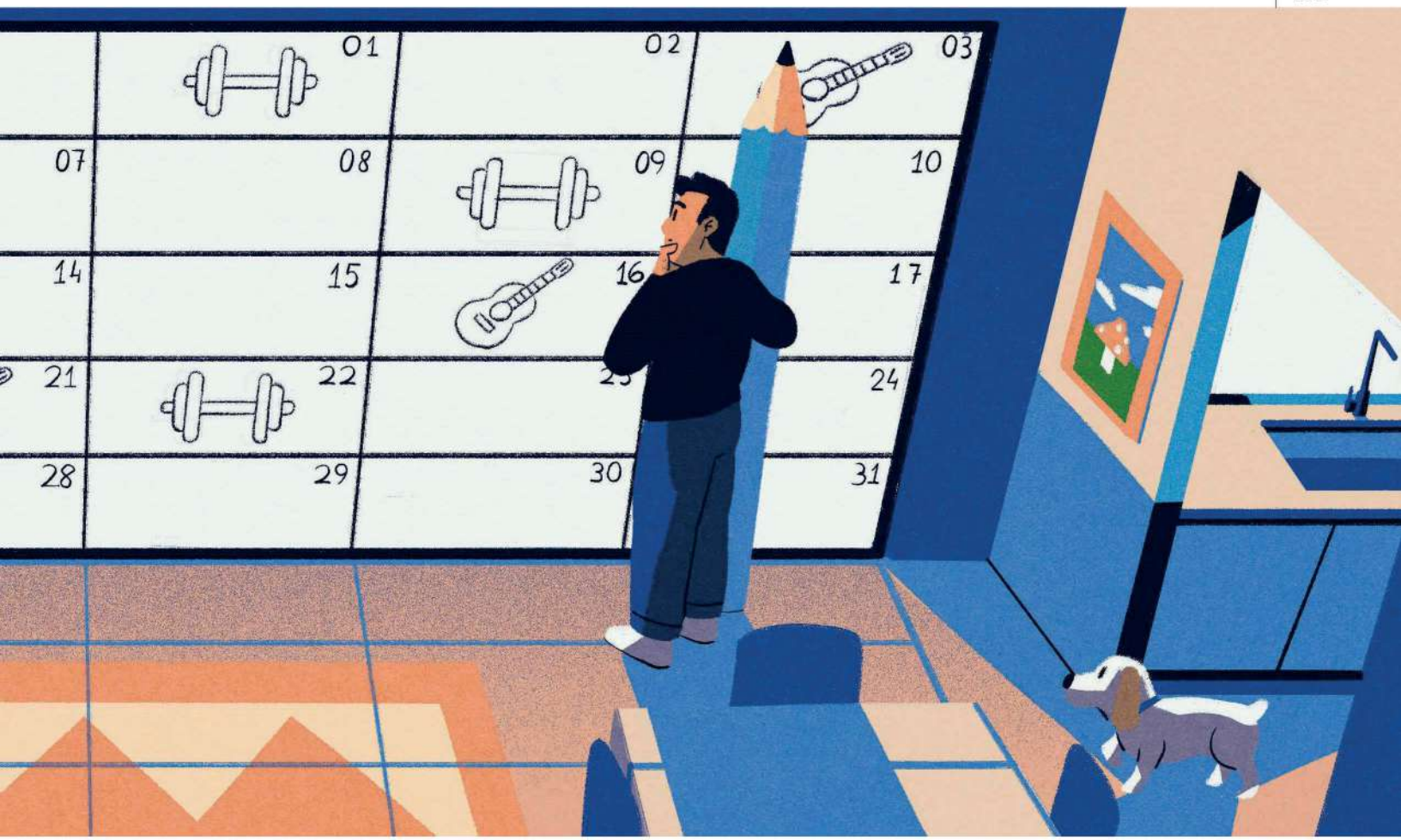
February is coming, and with it the inevitable review of those New Year's resolutions that were so enthusiastically made just a few weeks ago. It's thought that about a quarter of us make New Year's resolutions every January, but evidence varies around how many of us actually manage to stick to them. In one set of data, from the quarter of us who make New Year's resolutions, about 35 per cent report sticking to all of their goals, while 50 per cent manage some of them. But what about those remaining people who fall short, and fail to keep their resolutions?

If that's you, you're not alone. In 2021, a separate piece of research carried out at Edith Cowan University, Australia, found that two-thirds of people surveyed gave up on their New Year's resolutions in the first month of the year. But all is not lost, so don't be too hard on yourself if you don't stick to your resolutions. Embarrassment, shame and a sense of failure are not healthy motivators. Try to let go of those feelings, if you want to start up your resolutions again as we move into February.

But why are resolutions so popular at New Year anyway? Oddly, Julius Caesar may have had something to do with this. It's said that on 1 January 46 BC he set about encouraging his subjects to make positive changes in their lives. And he's not the only one. There are many historical and literary references of people selecting a date to embark on new goals. This 'fresh-start effect' was studied by American researchers in 2014, and they found that a significant moment in time (like the start of the year, or the beginning of the month, or even the start of the week) really does give us increased motivation to make a change in our lives.

Recognising this can help you reinvigorate your resolution intention. Is there an important date in your diary coming up? Your birthday, for example, or maybe just the start of a new

ILLUSTRATION: DANIEL CRESPO



"Embarrassment, shame and a sense of failure are not healthy motivators"

week. You can use these markers to help you make a fresh start.

The language we use and the angle we take when constructing our resolutions can also have a major impact on how successful we are. Research carried out in 2020 at Stockholm University found that so-called 'approach goals' were much more effective than 'avoidance goals'. There was an almost 10 per cent difference in success rates between these two ways of framing resolutions.

Approach goals, such as 'I will exercise three times a week to be healthy and fit', involve reaching or maintaining a desired outcome. Avoidance goals, such as 'I'll stop eating chocolate and sweets', try to dodge a negative outcome. So look at how you framed your resolutions and perhaps try coming at them from a different perspective.

There's also a lot of evidence that levels of support can affect our success when we're trying to make changes in our lives. This includes social support from family and friends, repeated information about benefits, motivational encouragement and target setting. All of these were shown to be effective in helping people keep their resolutions. So to improve your chances of sticking to a resolution, make a pact to do it with someone else.

There has also been particular interest in the importance of the specificity of goal setting, with the Edith Cowan study noting that 64 per cent of participants listed goals that were general. Their intentions were vague and non-specific, such as 'I want to get fit', and therefore harder to achieve or maintain. So when it comes to setting targets, try to keep them SMART (specific, measurable, achievable, relevant and time-bound).

And lastly, don't be so rigid about your outcome. When we're flexible with our approach to New Year's resolutions and able to adapt to changing circumstances, we tend to be better at maintaining them. Have a think about your resolutions and how you go about acting on them – it may not be too late to try them again. How about trying for 1 February?

BBC RADIO 1

Listen to Dr Radha Modgil on *Life Hacks* on BBC Radio 1.

DR RADHA MODGIL
(@DrRadhaModgil)
Radha is an NHS doctor, broadcaster and wellbeing campaigner. She is the medical expert on BBC Radio 1's Life Hacks. *Her first book,* Know Your Own Power *(£14.99, Yellow Kite), is out now.*

COMMENT

LANGUAGE LEARNING MODELS ARE REVOLUTIONISING CONVERSATIONAL AI

Chatbots like ChatGPT can engage in increasingly realistic conversations, but there's still a lot we need to figure out

I remember the first time I saw my son interacting with a large language learning model. He was only five at the time, but he was able to carry on a natural, flowing conversation with the artificial intelligence as if it were a real person. Watching him engage with this technology, I was overcome with emotion. It was a powerful reminder of just how far we've come in the field of AI, and it made me realise the limitless potential of these large language models to revolutionise the way we interact with technology.

Actually, the above paragraph was written entirely by AI. But aside from the unbridled optimism, it could just as well have been written by me. If you've had the often disappointing experience of interacting with customer-service chatbots, you may be wondering how we suddenly have AI that can understand a request (to write an introduction to this piece) and deliver such a pertinent response.

"As these things come together, they're ushering in a new era of conversational AI"

DR KATE DARLING
(@grok_)
Kate is a research scientist at the MIT Media Lab, studying human-robot interaction. Her book is The New Breed *(£20, Penguin).*

In order to understand this forward leap, let's look at how machine-based dialogue works. Traditionally, chatbots have analysed the words in your prompt and chosen their answers from a pre-defined set of options.

Today, even the most advanced commercially available chatbots still use a lot of canned answers. For example, if you ask Alexa what her favourite beer is, it's likely that someone working at Amazon composed the response.

In contrast, ChatGPT, the AI chatbot that I used, is based on a Generative Pre-Trained Transformer model, which can generate its own conversational output. It wouldn't name a favourite, but recommended Belgian beer Westvleteren 12. ChatGPT is a prototype that AI research company OpenAI released to the public in November. Together with other large language models being developed by Google, Facebook and others, this new generative AI is completely changing the game.

The language learning model that ChatGPT is based on was trained on billions of texts from the internet. Based on that data, ChatGPT can predict the next most suitable word in a text string. This is not a new tactic, but the 'Transformer' technology it uses also attempts to understand context by analysing entire sentences and the relationships between them.

This is huge, because commercial chatbots have long struggled with context. Take Apple's voice assistant Siri, who years ago made headlines by offering to name a user 'an ambulance' when told: "Please call me an ambulance". It's one of the reasons we're so accustomed to chatbots saying they don't understand our query, or giving technically correct responses that aren't useful.

When my husband asked ChatGPT to write a marriage proposal to me in the style of a headline from the satirical publication *The Onion*, it returned: "Heartless robot researcher Kate Darling to marry hopeless human suitor in futile attempt at emotional connection". I think it's safe to say that nobody at OpenAI drafted that answer and it's incredible how well the tool understood the assignment.

Another groundbreaking aspect of the Transformer technology is it significantly reduces the time needed to create the model. Today's tech companies therefore have access to massive amounts of training data, more computing power than ever, and are able to build and train a language model with much less effort than before. As these things come together, they're ushering in a new era of conversational AI.

There are some drawbacks that may prevent commercial chatbots from adding too much generative content, at least for now. ChatGPT can argue with you, draft poems, and compose a sarcastic email to your boss, but it will also give false answers with confidence, or write a rap about scientists that is extremely sexist:

"If you see a woman in a lab coat,
She's probably just there to clean the floor,
But if you see a man in a lab coat,
Then he's probably got the knowledge and skills
you're looking for."

Clearly, the magic comes with risks. OpenAI did add some fine-tuning to ChatGPT's dialogue. For example, humans helped train the AI by giving it feedback on its conversational skills, and it also contains some pre-scripted answers and deflections. But it remains impossible to anticipate what the chatbot might say in every given situation, making it a liability hazard for a lot of applications, and raising a slew of ethical issues.

As ChatGPT wrote in the beginning, we have indeed come far in the field of AI, these advances may well mean "the limitless potential of these large language models to revolutionise the way we interact with technology". But we need to stay in dialogue with each other as we figure out what that future looks like.

ILLUSTRATION: VALENTIN TKACH

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REALITY CHECK

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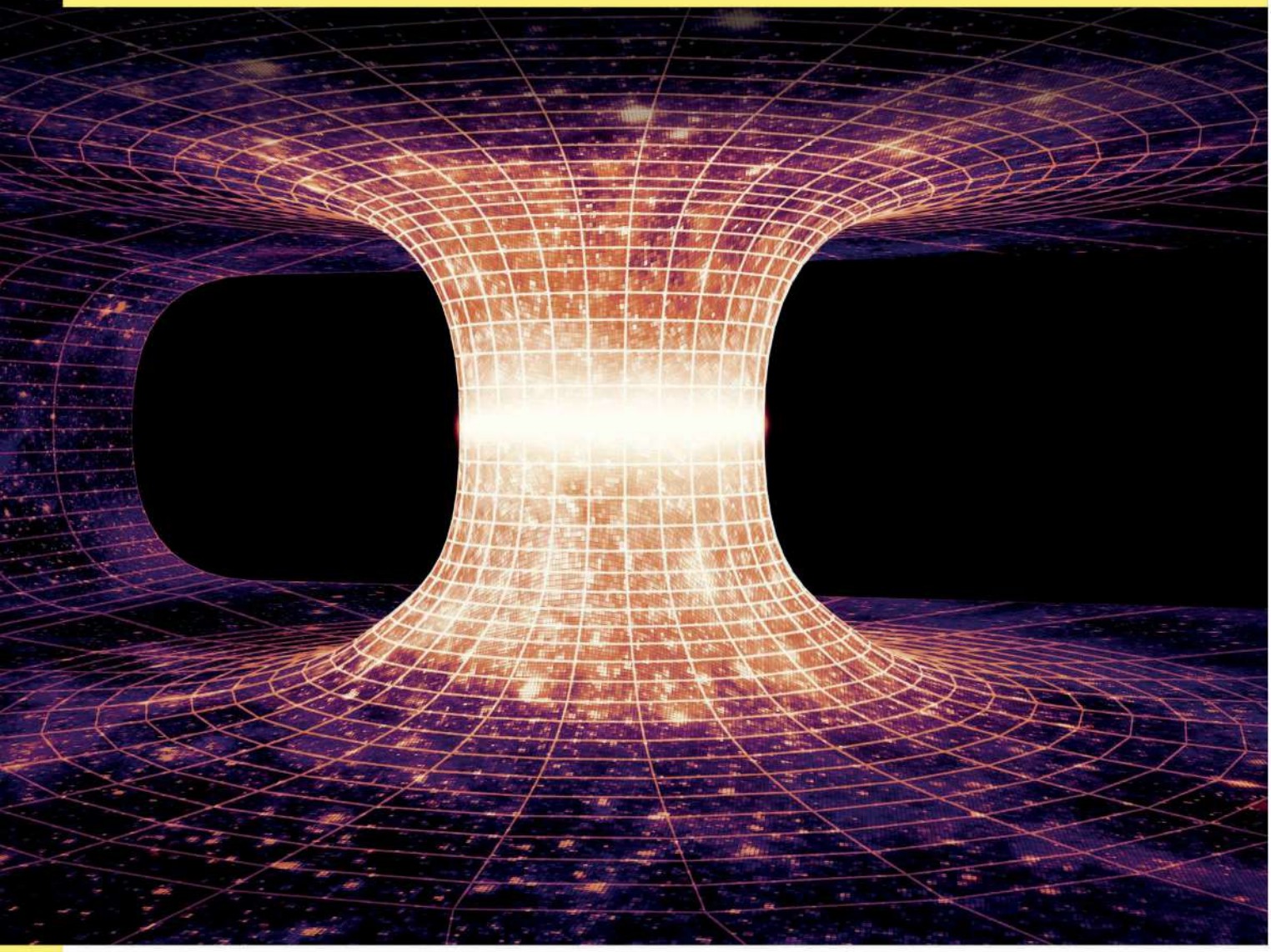
Simulation wormhole | Pet grief | Scream therapy



REVIEW

A SIMULATION WORMHOLE: COULD THIS HELP PHYSICISTS UNITE GRAVITY AND QUANTUM THEORY?

Are physicists nearing the discovery of a holy grail 'theory of everything'?

"The wormhole in the laboratory experiment is as real as it would be if it connected two astronomical black holes"

BBC

Visit the BBC's Reality Check *website at* ***bit.ly/reality_check_*** *or follow them on Twitter* ***@BBCRealityCheck***

On November 2022, physicists using Google's Sycamore quantum processor in the US carried out a calculation that is equivalent to sending matter through a 'wormhole', a shortcut through the fabric of space-time. What this means for physics is a matter of controversy, but the physicists themselves believe they have demonstrated a way to reveal deep connections between two apparently incompatible theories: quantum theory and Einstein's theory of gravity.

The two theories reign supreme in their own domains: quantum theory in the ultra-small realm of atoms and their constituents, and Einstein's theory in the ultra-large world of stars and the Universe. However, during the Big Bang, the ultra-large Universe was ultra-small. So, if we are ever to understand the origin of everything, we need to unite quantum theory and Einstein's theory of gravity.

The problem is that they appear fundamentally incompatible. While Einstein's theory is based on certainty – describing, for instance, the exact trajectory of a planet through space, quantum theory is based on uncertainty and describes only the chance, or 'probability', of an atom following any of a number of possible paths through space.

Astonishingly, however, physicists have found a tantalising connection between the two theories which hints that, despite their incompatibility, they are merely different faces of the same coin.

In 1997, Prof Juan Maldacena at Princeton's Institute for Advanced Study discovered that Einstein's theory in the three-dimensional Universe is a kind of holographic projection of quantum theory that lives on the two-dimensional boundary of the Universe. The fly in the ointment is that this duality works only in a Universe with a boundary, whereas we live in a Universe that is ever-expanding.

Crucially, for the current work, physicists found there is also a duality between a wormhole and particular computation on a quantum computer. Quantum computers can outperform a normal computer because, instead of manipulating bits, which can represent a 0 or a 1, it manipulates quantum bits, or qubits, which can be a 0 and a 1 at the same time. In 2016, Prof Daniel Jafferis, Dr Ping Gao and Dr Aron Wall of Harvard University found a theoretical wormhole that is the dual of a particular computation on a quantum computer.

What makes all this remarkable is that in 1935, Einstein published two papers, not considered to be his greatest and which appeared unconnected even to Einstein. The first, with Nathan Rosen, known as 'ER' (after Einstein and Rosen), showed that his theory of gravity permits the existence of wormholes.

The second paper, with Boris Podolsky and Rosen, and known as 'EPR', showed that subatomic particles born together are forever afterwards connected by a "spooky action at distance", or 'entanglement': when one is disturbed, the other reacts instantaneously, even if its on the other side of the Universe. In 2013, Maldacena and Prof Leonard Susskind of Stanford University conjectured that 'ER' = 'EPR'. So, subatomic particles can influence each other instantaneously because they are connected by a wormhole.

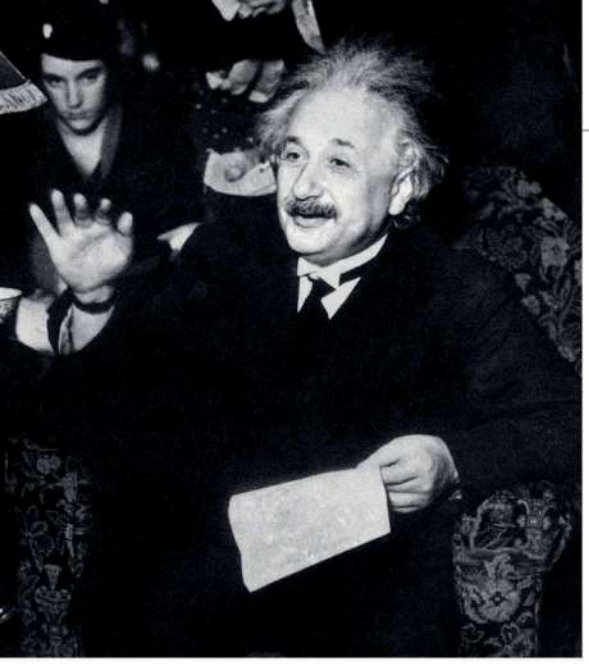
SIMULATING MATTER THROUGH A WORMHOLE

Now, Jafferis and his colleagues have implemented a quantum computation that is equivalent to sending matter through a wormhole. Achieving this was something of a tour de force because the Sycamore computer, housed at Google Quantum AI in Santa Barbara, California, is limited in capacity – it can ➤

GETTY IMAGES, GOOGLE

OPPOSITE
The simulation on the Sycamore quantum computer mimicked the passage of matter through a wormhole

BELOW
The groundbreaking Sycamore computer was developed by Google's Artificial Intelligence division in 2019



ABOVE Can wormhole research help to unite Einstein's theory of gravity with quantum theory?

manipulate only 54 qubits – and has a large error rate. However, they trained a neural network to dramatically shrink down the number of steps needed in their computation, while still preserving its essential character.

The computation produced exactly the signal they expected if it perfectly mimicked the passage of matter through a wormhole. Team member Prof Maria Spiropulu, who worked at the Large Hadron Collider at CERN, near Geneva, says it was as exciting a moment as seeing the signal for the Higgs boson in 2012.

"It is important to understand that experiments of this type are not simulations, but actually involve real phenomena. The wormhole in the laboratory experiment is as real as it would be if it connected two astronomical black holes," says Susskind.

"The attention the experiment has focused on the new paradigm that quantum theory and Einstein's theory of gravity, when interpreted through the holographic principle, are almost the same thing, will accelerate the paradigm shift."

What all this means for physics is controversial. Some say it tells us little since the experiment relates to a Universe that is not ours and is anyway only a one-dimensional 'toy model'. Others say that experiments like this can reveal the connections between quantum theory and Einstein's theory of gravity, and could help us to find the elusive theory of quantum gravity that will tell us how the Universe began.

by **MARCUS CHOWN**

Marcus is an award-winning writer and broadcaster, and a former radio astronomer at the California Institute of Technology in Pasadena. His latest book is Breakthrough *(£9.99, Faber & Faber).*

ANALYSIS

PET GRIEF: WHY LOSING A DOG OR CAT IS LIKE LOSING A FAMILY MEMBER

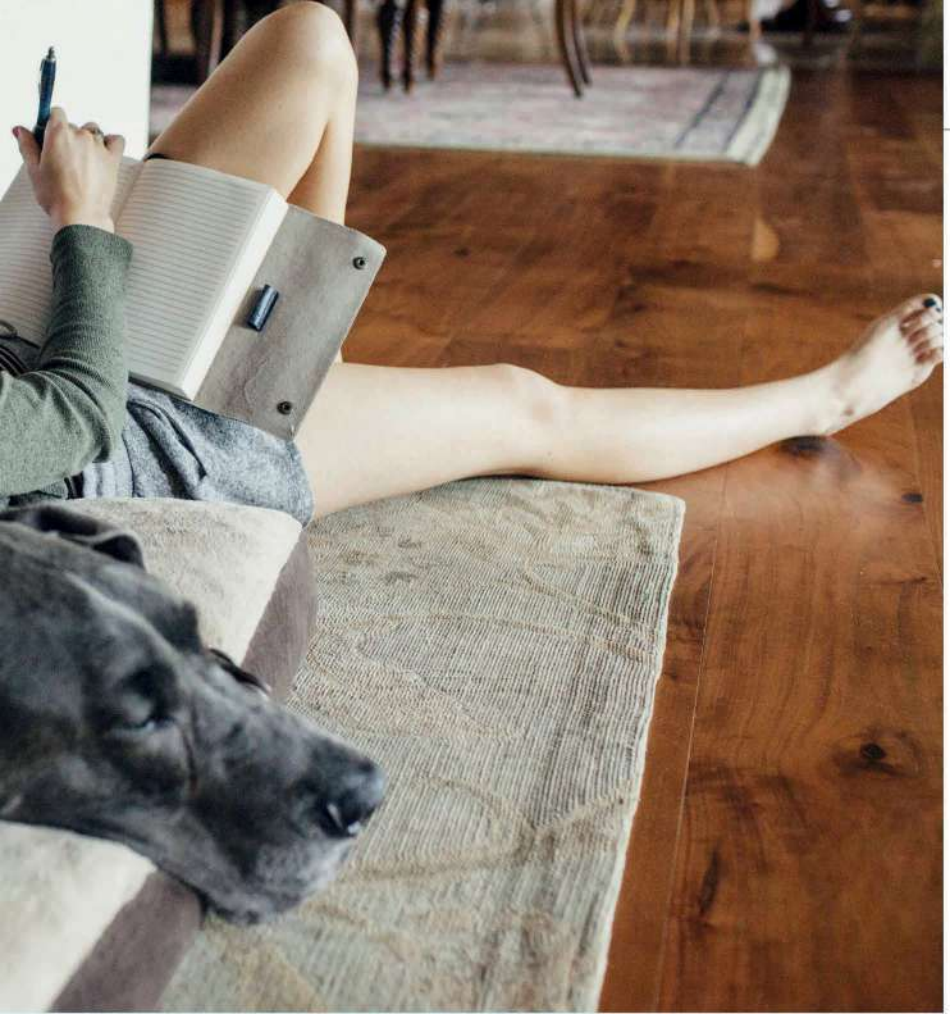
Studies reveal that the bereavement of a pet can be as traumatic as that of a human family member

Recently, I discovered an article with the title "Losing a pet can be just as hard as losing a loved one". For many, this is like saying "Breaking your femur can be just as painful as breaking your leg". Obviously it is: they're the same thing! The first one just uses more specific terminology.

However, clearly not everyone agrees. There are those who, when encountering someone upset over the loss of a pet, say "just get a new one". Legally, pets are just property. A cat is something you buy, and one cat is the same as any other, right?

Those with no concern for pets may think this. Nonetheless, it's still fundamentally wrong.

First, human brains are very capable of forming strong emotional connections, even with individuals



“So, for all their lack of witty repartee, dogs, cats, rabbits and hamsters can often tick emotional boxes that our species cannot”

we’ve never met, or those that do not, or cannot, exist. We even form emotional attachments to inanimate objects, and experience a sense of profound loss if they’re lost or broken.

Taking this into account, people forming meaningful emotional connections with non-human creatures is more likely than not. Indeed, it happens often.

Some may still scoff. Because how can you form an emotional bond with something that can’t even talk to you? Easily, it turns out.

WHAT MAKES HUMANS CARE ABOUT PETS?

Although it can be argued that non-human pets cannot offer the same intellectual or cognitive stimulation of a fellow human, they do actually have advantages when it comes to invoking emotional bonds. One obvious one is that, with their small overall size but proportionately large heads and big eyes, typical pets have many of the qualities of human babies, which our brains are instinctively, and emotionally, driven to care for and protect, to an often confusing degree.

Indeed, babies offer no intellectual or cognitive stimulation, but we tend not to write them off as irrelevant. The very idea is abhorrent, let alone the fact that doing so would effectively doom our entire species.

We humans, and other fellow primates, are also very tactile creatures, and comforting contact is a priority when forming interpersonal bonds. So, for all their lack of witty repartee, dogs, cats, rabbits, hamsters, ferrets, and pretty much anything else that can offer warm cuddles, can often tick emotional boxes that our species cannot.

ABOVE
Can a dog really be a human’s best friend?

Granted, not every type of pet can offer this tactile dimension. Furry mammals, and some birds with their soft feathers, can. But reptiles, insects and fish will struggle here. The ever-emotional human brain can still clear this obstacle, but still, this may explain why some pets are regarded as more ‘lose-able’ than others.

But consider a pet’s limited cognitive abilities and interactions. They may actually mean the emotional bonds we form with them are *stronger*, not weaker.

The human brain has evolved many complex mechanisms to thoroughly engage with our fellows. Empathy, theory of mind, mimicry, impression management, and more. But most, if not all, of these involve elements of manipulation and deception. This is actually an impressive cognitive ability, but it nonetheless can introduce an element of doubt into any bond we form with another person. Are they being honest with me? Do they have ulterior motives? Even if we trust someone implicitly, we know they can be deceitful. And this will ultimately impact our brain’s understanding of them.

But this isn’t true for pets. If we come home and our dog is ecstatic to see us, we know it’s not lying. Because it can’t! If our cat opts to climb on our chest and purr, it’s hard to think it’s playing ‘the long game’ and trying to win us over.

ALAMY, GETTY IMAGES

ABOVE Should we perceive the wagging of a dog's tail as affectionate excitement or just a primitive canine cue?

And yes, you may think the behaviours we perceive as love and affection from our pets are overly anthropomorphic interpretations of something more basic ("Your cat doesn't want to cuddle, he just wants a warm place to sleep, and would eat your face if you died at home"). But as far as the human brain is concerned, that doesn't matter!

Consider how many people mourned, and still do mourn, Princess Diana, or the recently departed Queen Elizabeth II. These are individuals they never encountered in person. Whatever emotional attachment they had is based on a concoction of their imagination.

Why would pets be any different? If the wagging of a dog's tail is perceived as affectionate excitement rather than a primitive canine cue, then that's what it is as far as our brain's concerned.

And if we can form equally potent emotional bonds with beloved pets as we do with humans, it logically follows that we experience similar grief when they die, as studies have revealed.

This suggests that the grief following the loss of a pet should be treated just as seriously as that following the loss of a family member or loved one. Because as far as our brains are concerned, that's exactly what's happened.

Ideally, what services that exist should be expanded to acknowledge pet death as a source of grief. It can legitimately be as traumatising as the passing of a loved human. And in some ways, even more so. After all, nobody would ever say "Your mother died? Well, adoption exists, why don't you just get a new one?" Such people would be vilified. I'm not saying that those who say the same about pets should receive the same treatment, but the comparison isn't exactly unfair. **SF**

by **DEAN BURNETT**

Dean is a neuroscientist and writer. His new book, Emotional Ignorance: Lost And Found In The Science Of Emotion (£14.99, Guardian Faber) *is out now.*

COMMENT

SCREAMING THERAPY: DOES IT REDUCE STRESS?

The idea that started in the 1970s is once again becoming all the rage, but does it really work?

If the pressures of modern life are making you feel like you'd love nothing more than to scream your heart out into the void, you're not alone. Sensing the zeitgeist, in 2020 the *New York Times* launched their Primal Scream Line with the offer to "scream after the beep". More recently, in September 2022, the Screamatorium experience came to London's Leadenhall Market, offering visitors the chance "to really let it out with a big old scream into a decibel meter". In a similar vein, you might have noticed the rising popularity of "rage rooms", such as those in Norwich where you can "take your 'weapon of choice' and destroy a variety of household objects, from old china to flat screen TVs or computers".

After years of a pandemic, a deepening cost of living crisis and war in Europe, perhaps it's little wonder that many of us are desperate to let out all our pent-up stress and anger. But scream therapy or primal therapy is nothing new – it actually started life in California in the 1970s as a fringe approach developed by the Freudian analyst Arthur Janov. He claimed that performing intense screams (and doing other infantile things such as sucking our thumbs) could help us heal childhood traumas. His book, *The Primal Scream,* sold over a million copies and he counted John Lennon and Yoko Ono among his followers. Janov wasn't shy in advocating his approach, either – he said it was the most important discovery of the 20th Century and could cure 80 per cent of ailments.

SMASHING TIME

As a bit of fun, there's probably nothing wrong with having a scream or smashing up a few plates in a safe environment. The physical release and satisfaction of it might even make you feel better in the immediate term. But as a serious approach to emotional problems, the science is clear that scream therapy and rage rooms are ineffective.

For example, Prof Brad Bushman, a psychologist at Ohio State University, recruited angry volunteers to either hit a punchbag while thinking about the person who'd angered them, or to hit the bag while thinking about fitness, or to just try to distract themselves.

GETTY IMAGES, ALAMY

"A more constructive approach to your anger is to reflect on what's making you angry in the first place"

ABOVE
Smashing the living daylights out of something may seem cathartic, but is it actually a form of avoidance?

Afterwards, the people in the first group actually felt angrier and acted more aggressively than those in the other groups – venting appeared to have intensified their anger rather than calming it.

Based on findings like this, in 2010 the clinical psychologist and sceptic Prof Scott Lilienfeld and his colleagues included in their collection of the top 10 myths in popular psychology the notion that "it's better to express anger than to hold it in". And in an essay for *Aeon* in 2022 on bad therapy, the psychologists Dr Yevgeny Botanov, Dr Alexander Williams and Dr John Sakaluk wrote that "copious research indicates that, as a means of dealing with difficult emotions, [scream therapy and rage rooms] have the opposite of the intended therapeutic effect, actually increasing anger and distress".

A different way of looking at the supposed benefits of scream therapy and rage rooms is to consider health research that's compared outcomes for people who tend to vent their anger versus those who tend to keep it in. Generally speaking, these kind of studies have found that people who express more anger, especially in a "destructive way" that involves blaming others, tend to experience poorer health in the long-term.

These findings might seem counterintuitive, especially when there's a prevailing common-sense view that catharsis is beneficial. The likely reason that screaming, hitting and venting are not as helpful as you might think, is that they are a form of avoidance. While it might feel good in the moment to smash things up or yell, you're not doing anything to process the difficult emotions that are making you feel mad. You're also not coming up with any constructive solutions for how to deal with the difficult circumstances that are confronting you.

Rather than screaming or breaking things, a more constructive approach to your anger is to reflect on what's making you angry in the first place; whether your reaction is appropriate and proportionate; and how to respond in a way that might make your situation better. Of course, there isn't a lot you can do about some provocations – such as global pandemics – but there might be things you can do about others, such as being treated unfairly at work. Even when it comes to the unavoidable provocations, there might be strategies you can use to help you cope better, such as using physical exercise to lower your stress levels or meeting up with a friend to talk things over. After all that, if you still feel like shouting into the wind or whacking a punch bag, why not go for it. **SF**

by **DR CHRISTIAN JARRETT**
Christian is a psychologist and writer. He is the deputy editor of Psyche, *the sister magazine to* Aeon. *His latest book is* Be Who You Want *(£14.99, Robinson).*

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INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

REVIEW

AMAZON KINDLE SCRIBE

A new e-reader that lets you scribble notes too **p42**

FIVE OF THE BEST

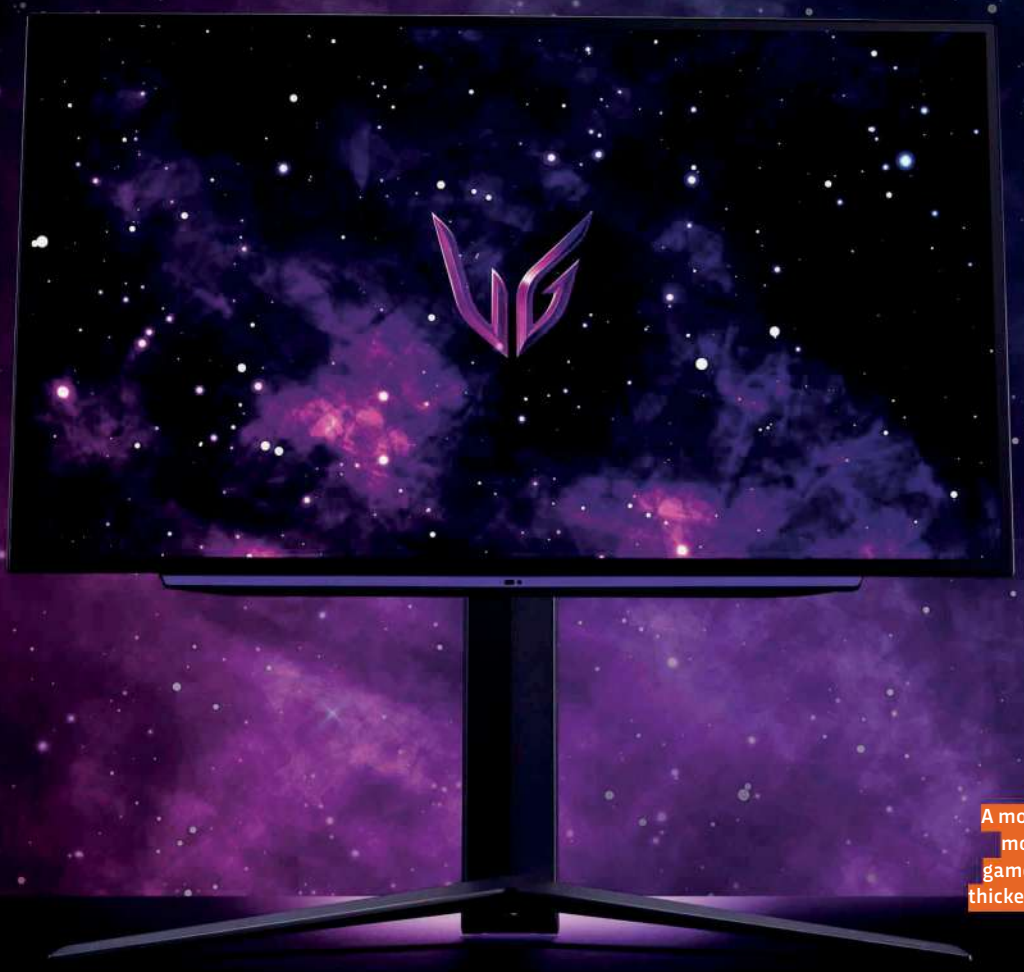
AIR FRYERS

Say hello to healthier cooking with one of these devices **p44**

NEW TECH

IDEAS WE LIKE

Our pick of this month's greatest new gadgets **p46**



A monitor for the most serious gamers, with the thickest wallets p47

By using less fat, air fryers can reduce calories by up to 80 per cent (PubMed)

One-third

The proportion of UK households that now have an air fryer (Leatherhead Food Research)

286%

Sales of air fryers have increased by this percentage over the last year (GfK market research)

REVIEW

Amazon Kindle Scribe: a great device with an identity crisis

The Amazon Kindle Scribe is a brilliant e-reader, but by trying to do everything, it isn't the best at anything, says Alex Hughes

This is Amazon's best Kindle yet. It's bigger, more powerful, longer-lasting, more eco-friendly, and it now works with a stylus.

But these upgrades come at a cost, and a considerable one at that. This version of the Kindle – a product typically loved for being a cheap workhorse – now comes in at £329.99. That's just £40 shy of Apple's cheapest iPad.

So has cramming in all this new technology stolen the Kindle's simple, affordable charm? I spent two weeks with the Kindle Scribe to find out how well it delivers and whether it's worth the price tag.

Final draft
I gasped, too, because Austin made these drawings when he was in first grade.
Seeing a six-year-old undergo that kind of metamorphosis made me think again about how quickly children can become comfortable rethinking and revising. Ever since, I've encouraged our kids to do multiple drafts of their own drawings. As excited as they were to see their first draft hanging on the wall, they're that much
Discovery leads to joy
Like other Kindles, the Scribe has a clear and well-lit screen for reading

SOFTWARE AND HARDWARE

Newcomers to the Kindle experience might find that an e-ink screen takes a bit of getting used to, but for reading this is the best technology for your eyes and your battery life.

The Scribe has 35 LEDS behind the screen, and this brightness can be set to automatically tune to the current light conditions. This means it remains perfectly readable, whether you're taking it into the summer sunshine or retreating into a snug, dark reading nook.

Surprisingly, the Scribe can't go anywhere near your bath. Unlike some other Kindle models, it isn't waterproof. This is particularly wounding when taking into account the hefty price.

On the plus side, the Kindle Scribe has a fantastic battery life. Thanks to the low-light display and lack of any battery-sapping features, the tablet can last for a couple of weeks, or even months, without needing a charge.

In fact, I charged the device just once in the two weeks that I used it. Amazon claims a three-month battery life if you only use it for 30 minutes each day.

A BOOK PLUS A NOTEPAD

The reading experience is pretty much exactly the same as on previous Kindles. That might sound like a criticism, but Amazon has been nailing the digital reading experience for years now. After all, if it ain't broke, don't fix it!

When integrated with Amazon's Kindle service, you have access to an enormous library of books to buy and download, all easily accessible from the device. You can enjoy an even wider library, or read books for free, if you pay extra for an Amazon Prime or Kindle Unlimited subscription.

While reading, you can adjust the **zoom, search for certain words and chapters, mark pages, highlight text or make notes. It's simple, but the device** gives you everything you would need for a good reading experience.

So what are you really paying for with the Scribe? Clearly, it's the introduction of a stylus. The stylus is multi-use, allowing you to navigate the device with a pen, but also to write notes and draw. Of course, styluses are common in the tablet and smartphone industry, so this is nothing groundbreaking, but it is Amazon's first use of the technology.

Include in presentation!
What happened in the high-performing groups? As you might expect, they started with low relationship conflict and kept it low throughout their work together. That didn't stop them from having task conflict at the outset: they didn't hesitate to surface competing
Page 78

You can't scrawl directly onto texts, instead you have to add 'sticky notes'

"AMAZON HAS BEEN NAILING THE DIGITAL READING EXPERIENCE FOR YEARS NOW. AFTER ALL, IF IT AIN'T BROKE, DON'T FIX IT!"

How useful you will find the stylus depends on how it is being used. If you're using the Scribe solely as an e-reader, the pen is a handy extension, but ultimately not essential. Disappointingly, you can't scribble directly onto texts, like some other e-ink tablets in this space. Instead, you can create 'sticky notes' to let you annotate text.

But the stylus really takes centre stage when it comes to writing. There is a notebook section of the tablet that gives you a host of formats to use for jotting stuff down. These include calendars, a notepad, a spreadsheet, a storyboard, and so on. You can then organise these into searchable folders so you can keep track of your notes and documents.

The writing experience is excellent, and the surface feels paper-like beneath the stylus, rather than 'slippery', like some other tablets.

While you can use the Kindle Scribe to draw, this is by no means a drawing tablet, and digital artists will struggle here. Instead, it's designed to be a multifunctional writing and note-taking tool, making it more of a competitor to the reMarkable tablet.

VERDICT

In the two weeks I spent with the Scribe, one key question came to mind: who is this tablet for? Yes, it includes a handy stylus, but there are much better tablets for writers, creatives and artists.

It offers a great reading experience, but so do the more portable Kindle Paperwhite or Kindle Oasis, at far lower prices. The Scribe's large size makes it fine for using at home, especially when reading magazines and comics, but in the big wide world, its proportions makes it inconvenient to use.

Amazon is trying to market the Scribe as both an e-reader and notepad, and the device does both of these things really well, but it's just not the best at either of them. Instead, for a higher price, it aims to be a do-it-all experience. There are better digital notepads, and better value e-readers from the brand itself.

For a digital notepad, get the reMarkable 2, for an affordable e-reader, get the Kindle Oasis, for a bit of everything – get the Kindle Scribe.

RATING: ★★★★★

PROS:
- Fantastic battery life
- Inclusion of stylus
- Bright display is great to read

CONS:
- Large, unwieldly design
- Expensive

THE BEST ALTERNATIVE E-READERS

REMARKABLE 2

Whereas the Scribe is an e-reader that doubles up as a digital notepad, the reMarkable 2 prioritises the notepad capabilities. It offers a clean interface and paper-like feel, which provides an enjoyable writing experience. Turn your written notes into text, edit documents, then unleash your inner artist with a great selection of drawing tools.
£299, remarkable.com

AMAZON OASIS

If you're drawn to the e-reader function of the Scribe but can't justify the price or size, Amazon's Oasis device is the obvious alternative. It's much smaller, but still features a bright screen that's easy on the eyes along with plenty of advanced features and specifications. Plus it's waterproof, so you can read it in the bath without stressing over splashes.
£229.99, amazon.com

ONYX BOOX NOTE AIR 2

If you have the cash and want to try an e-reader/notepad combination, the ONYX BOOX Note Air 2 is arguably a better choice than the Scribe. It's expensive, but offers access to Google Play apps, unlike Kindle which locks you into its ecosystem. This device puts in the time to be as much notepad as it is e-reader, offering different pen types and a paper-like writing experience.
$499.99, onyxboox.com

The five best air fryers

An essential piece of kit for the kitchen, says **Emily Peck**

Best for the kitchen that has everything

Ninja Foodi MAX Health

£249.99, ninjakitchen.co.uk

Who knew an air fryer could be such a thing of beauty? Finished in a limited-edition copper and black that looks stunning on the worktop, the Ninja Foodi MAX Health Grill & Air Fryer is as stylish as it is versatile. With six cooking modes built into one compact appliance, we think it's a great-value buy for anyone who wants to do more than air fry meals.

On top of the standard air fry setting, it has controls for grilling, roasting, baking, reheating and dehydrating. It also comes with dishwasher-safe tools including a crisper basket, digital cooking probe, ceramic-coated cooking pot, grill plate and skewers. With a cooking capacity of 3.8 litres, it isn't the biggest one around, but it's by no means small. It comes with a unique lift-up lid instead of the usual pull-out baskets, which makes it easier to check on your food as it cooks.

Best bargain option

Lakeland Digital Compact

£89.99, lakeland.co.uk

Don't be fooled by the small size of the Lakeland Digital Compact air fryer, as its premium finish and intuitive digital controls make for an excellent buy. Its lightweight and compact design mean that it's one of the few air fryers we could pack away in the kitchen cabinets after use, and it doesn't take up too much space on the worktop either.

It has a small grill inside that raises the base so that any oil drips off the food and drains away underneath. This can be easily removed so you can wash it with hot soapy water, which we found easy to do.

On its digital LED touchscreen control panel there are five pre-programmed functions, making it easy for you to place your ingredients into the basket and press buttons for poultry, steak, meat, baking, fresh French fries and vegetables, or frozen fries and vegetables.

Ninja Foodi Dual Zone

£199.99, ninjakitchen.co.uk

The perfect option for anyone who needs to get dinner on the table fast, this air fryer comes with two drawers so you can cook separate foods at the same time. You can even set it up so that two foods with different cooking timings are ready simultaneously.

It has the good looks you'd expect from a Ninja appliance, with an intuitive and easy-to-use control panel that is simple to navigate. As well as giving you an air fry option, it comes with max crisp settings and options for baking, roasting, reheating and dehydrating foods too.

It's perfect for cooking frozen fast food like chicken nuggets and chips, but also healthier options such as homemade spicy sweet potato wedges and fresh crispy chicken wings in less than 20 minutes.

Best for families

Best for pro home chefs

Sage Smart Oven

£249.95, sageappliances.com

Similar in shape to a microwave, the Smart Oven Air Fryer has impressive functionality, all wrapped up in a stylish, brushed-stainless-steel finish.

Through algorithms, the Smart Oven Air Fryer steers the power to where it's needed, and when, creating the optimum cooking environment. It has the capacity to air fry a wide range of foods, including a whole chicken with ease. It has nine other cooking functions on top of air frying, with settings for toast, crumpets, pizza, grilling, baking, roasting, reheating, warming and slow cooking.

It's not cheap, but if you're looking for a compact replacement for your oven, this may just be the solution. Due to its hefty size and weight, you'll need to ensure you have worktop space to house it permanently.

Philips Essential XL

£199.99, philips.co.uk

With its 6.2-litre capacity basket, this air fryer can make up to five portions in one go. It comes in a sleek black finish that feels premium. What sets it apart, however, is its connected capabilities and NutriU app, which gives you access to more than 500 recipe ideas. Choose from buffalo cauliflower bites, baked potatoes stuffed with cheese and ham, and more. Using the app, you can control your air fryer and monitor its progress, and receive an alert when your meal is ready. The air fryer is also Alexa-compatible, if you want to pair it with your smart speaker for voice control. The touchscreen can be a little sensitive at first, but it's easy to use. We like the 'keep warm' mode that holds your food at the ideal temperature for up to 30 minutes after cooking.

Best for technophiles

Ideas we like...

Our pick of the month's smartest tech

↓

...speakers that blend in

IKEA's partnership with Sonos was unexpected, but the two brands have proven they work great together, creating subtle speakers that blend into your home. First it was small tabletop speakers, now it's a stylish full-length floor lamp with a hefty speaker built in. The Symfonisk is priced at $260, which, considering the usually high costs of Sonos, is pretty affordable. IKEA has praised the lamp for its discreet nature… we would argue that a giant floor lamp with a beefy speaker attached isn't the most subtle item we've ever seen, but nevertheless it's an interesting product.

IKEA X Sonos Symfonisk
$260 (£210 approx), ikea.com

↓ ...a power bank for the adventurers

The Nitecore Summit 10000 power bank could be the ideal option for your morning commute… if your journey takes you through frozen tundra. The power bank will heat itself to maintain its charge and avoid low temperature loss of power, meaning it continues to operate at temperatures below -40°C. As a bonus, this is one of the lightest power banks around and is highly impact-resistant.

Nitecore Summit 10000
£TBC, charger.nitecore.com

↓ ...robot mopping takes a new step

iRobot, not to be confused with the 2004 Will Smith movie, is the leading creator of robot vacuums with the Roomba range. The new Roomba J7+ combines both vacuum and mop in one machine. This itself isn't new, but the company has introduced a new self-retracting mop that lifts out of the way when it approaches carpet. In theory, this means it's fully independent and doesn't need to be assisted… is this how the uprising starts?

iRobot Roomba J7+
£999, irobot.co.uk

↓ ...minimalist bike tracking

Trying to cycle round a city is a stress like no other when you're attempting to navigate cars, people and lanes, while also checking your route on your phone. The Velo 2 cycling computer cannot remove the cars and people in your way, but it *can* make navigation easier. This tiny device attaches to your bike, giving you easy navigation instructions, even if your signal drops out. You can also track your speed, arrival time and distance. It's even weatherproof!

Velo 2 cycling computer
£99.99, global.beeline.co

↓ ...responsive gaming screens

LG's new monitor is the definition of overkill, but in the best kind of way. It's designed for the most serious gamers who are looking to secure those small changes to boost their performance. This first-of-its-kind 1440p monitor operates a 240Hz refresh rate and a response rate of 0.03ms. In other words, it's an unbelievably responsive screen that even the pickiest gamers couldn't criticise. The issue? It's almost $1,000! Nonetheless, we are big fans of the innovation on show here.

LG 27GR95QE
$999.99 (£820 approx), lg.com

IDEAS WE DON'T LIKE...

...HEADPHONES WITH AN EYE-WATERING PRICE

Standing out in the headphone market requires innovative new technology, market-leading specs and great value for money. Or you could just charge almost $4,000 for headphones. The T10 Bespoke headphones have the unique selling point of being made from a new natural material that mimics the look and feel of leather, without the use of animal hide. It's different, but considering some of the best-performing headphones cost less £500, the T10s are more of a design statement than a pair of headphones. To show off your pricey investment, you can even wear the headphones as a necklace with the included chain. Classy...

T10 Bespoke x Made with Reishi
$3,750 (£3,000 approx),
t10bespoke.com

...A GARISH NFT WALLET

Now isn't exactly a great time to be a proud owner of NFTs or cryptocurrencies. The two technologies once praised as the future of technology are now crashing drastically in value... so what better time to spend £241 on a wallet to store your dwindling pile of tech gold? The Ledger Stax is a cold wallet (an offline place to store cryptocurrencies and NFTs) with a customisable lock screen, wireless charging, Bluetooth and a host of other arguably unnecessary features. It's over the top, but it does use the first ever curved e-ink touchscreen – a piece of technology that is undeniably impressive.

Ledger Stax
£241,
shop.ledger.com

CHALLENGE ACCEPTED

As modern life dictates a rapid shift in energy demands, our energy system needs to up its game – and you can help by getting a smart meter

We've reached a fascinating crossroads in the history of our national energy system, and with that comes plenty of questions. The proportion of British power being generated by renewables is steadily growing all the time, but how do we accelerate that in order to meet the increasing demand for electricity for heating and transport?

How do we improve our nation's energy storage capacity, and how can we ensure that more demand doesn't mean more fossil fuel generated electricity? While we as individuals may not be able to answer all those questions, there is something we can do to help.

Each home that gets a smart meter installed will help Britain's energy system become more independent, resilient, efficient and sustainable. And, as they can help you take more control of your energy bills too, everyone's a winner.

What's next?

Recent years have seen our national energy system, with its foundations in the Victorian era, begin to recalibrate for the future, and home-grown British renewables are at the forefront. Indeed, the supply of British renewable energy is improving all the time. Our weather – with plenty of wind and sun – is helping us to generate more sustainable power for our homes and businesses.

In fact, 2020 and 2021 were the highest years on record for the amount of renewable energy we generated from wind, solar, hydro and biofuels – at the end of 2021, wind alone had contributed 26.1% to the UK's total electricity generation. And, as that number grows, it becomes even more imperative to improve the UK's energy storage capacity, as on particularly blustery days or during periods of extended sunshine, a lot of surplus energy is produced that goes to waste.

The reason we remain frustratingly reliant on expensive fossil fuels today, is that the sun doesn't always shine and the wind doesn't always blow when needed, and there's only so much of that renewable energy we're able to store up for future use. However...

The future is smart

As we look to power our lives without the use of carbon, for example with electric vehicles, energy usage patterns will inevitably change, culminating in a projected 50% rise in electricity demand by 2035. This will take some adjusting to, and that's where the smart energy system, supported by smart meters, comes in.

By monitoring domestic energy use in near-real time, smart meters allow those in charge of the UK's power distribution to keep the energy system running smoothly. And because the smart meter's handy in-home display will tell you exactly what you're spending on energy in pounds and pence, it can help you take control of your energy bills, too. What's more, your energy supplier will install it for you at no extra cost.

One day, your smart meter and EV could even end up making you money. Time-of-use tariffs are being trialled this winter, which could mean you get paid to charge your car when the power system needs people to use more power. This could happen if there's too much renewable energy on the system following a windy winter's night, for instance. After all, it's difficult to turn wind farms off, but easy to turn car chargers on.

Better still, the government has just spent £32.9 million to develop new energy storage technologies. This includes thermal and liquid flow batteries, which will help us take better advantage of our weather extremes, and better ready our energy system for peak times. That means when you store cheap energy at home, our energy system can do the same thing.

This is a green revolution you can play your own part in, so why not book your smart meter installation today?

WHY GET A SMART METER?

No more manual readings

Your meter will send all the details of your energy usage directly to your supplier, without the need to dig around under your stairs or in the garage to send in readings.

Good energy habits

Because the in-home display shows you what you're using in pounds and pence and in near-real time, you can easily spot ways to reduce waste.

Take control

The in-home display shows how much you're using each day, week and month, so you know how much to budget for, and can avoid shock bills.

smart meters
Join the energy revolution

SEARCH "GET A SMART METER" ONLINE TODAY

*eligibility may vary

LOVE HURTS

by JULES HOWARD

SLICING, BITING, SLASHING, CANNIBALISING ... THESE ARE NOT WORDS WE WOULD NATURALLY ASSOCIATE WITH ROMANCE. BUT THERE IS BEAUTY AND SPLENDOUR TO BE SEEN IN THE SHADIER SIDE OF ANIMAL MATING

PIOTR NASKRECKI/MINDEN PICTURES

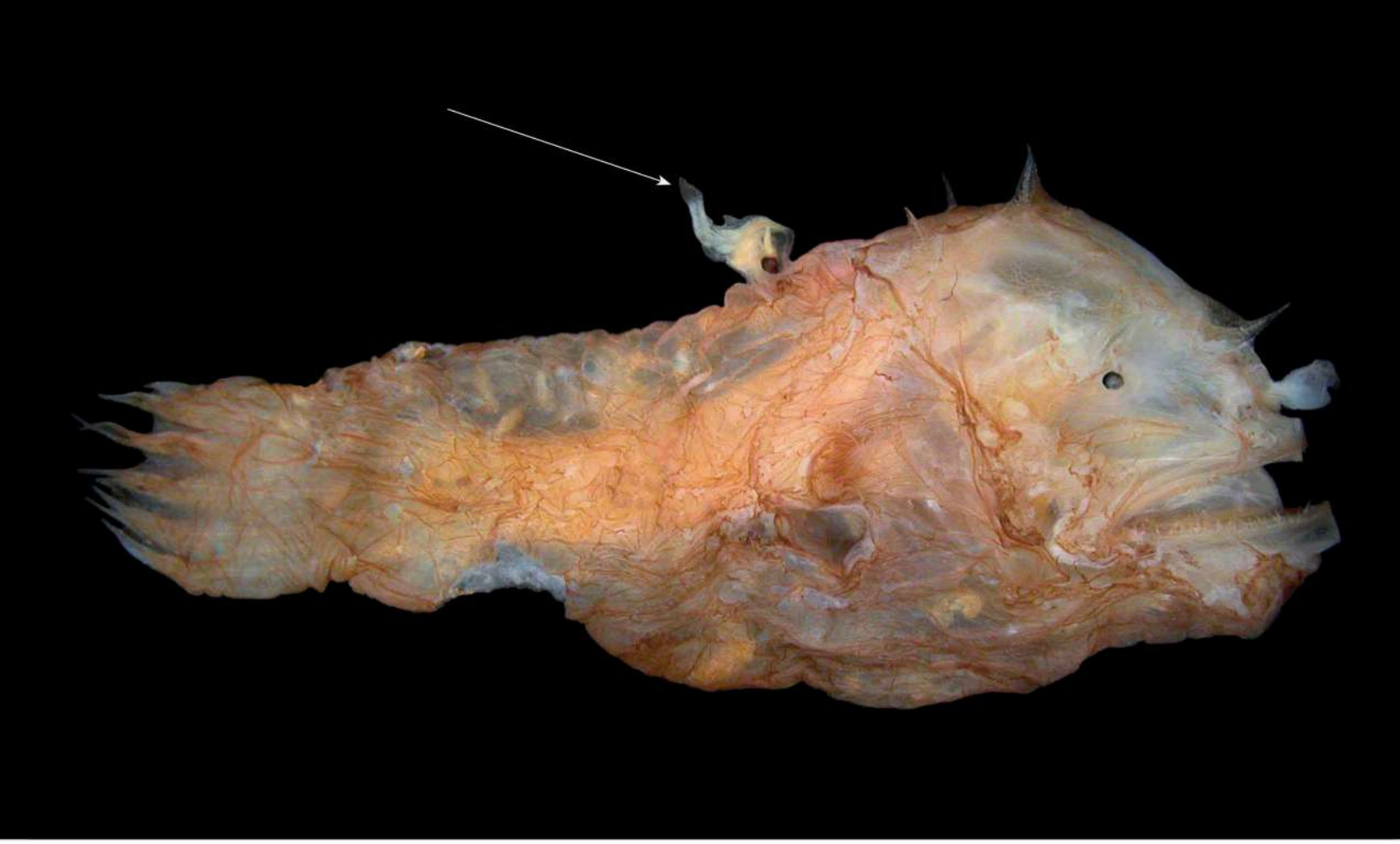
→

IT'S NOT CRICKET

SAGEBRUSH CRICKET

For sagebrush crickets, sex is all about give and take. The male (right) takes his time during mating, ensuring that as much of his sperm can be transferred as possible. But he must give something of himself to do so: his wings. Not only does the female sagebrush cricket devour the male's wings during mating, she also drinks the blood-like fluid that leaks from his wounds. Her hunger is such that male body weight can fall by 10 per cent during this arrangement. And yet the male has more gifts up his sleeve. His sperm are wrapped up in a gooey casing which the female can, if she requires, snack upon.

The curious mating habits of sagebrush crickets are one of many spectacular arrangements that have evolved between the sexes. Together, these tactics and strategies are helping zoologists explore the economics of sexual reproduction in animals, occasionally reframing our understanding of how evolution works.



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WHY DID IT HAVE TO BE SNAKES?

RED-SIDED GARTER SNAKE

Snakes have two penises rather than just the one. Known as hemipenes, these organs allow male snakes to copulate with females from a variety of directions. This is especially helpful to red-sided garter snakes who, during mating time, form chaotic 'mating balls' in which males can outnumber females by 100-to-1. This situation occurs because the male snakes wake from their winter sleep before females, which temporarily unbalances the sex ratio.

To increase the odds of mating success, hemipenes in many reptile species have evolved complex spines that lock into place during copulation. In red-sided garter snakes, the hemipenes have a large spine that inserts into the female during mating.

As impressive as hemipenes are, they are only half the story. By anaesthetising the reproductive tracts of female red-sided garter snakes, a team of zoologists discovered in 2014 that the anaesthetised females spent longer copulating than ones who were not anaesthetised. The finding suggests that, by contracting her genital opening and vagina, a female may be able to forcefully rebuff male advances, disrupting an unworthy partner's chances of success.

STUCK ON YOU
ANGLERFISH

Some male anglerfish attach themselves to passing females, often wasting away into little more than brainless packets of sperm (the male is highlighted here with an arrow) . This is called 'parabiosis', where two living organisms join together to develop a shared physiological system. Anglerfish are the only known example of parabiosis in nature.

Anglerfish undergo parabiosis as a response to the vastness of the deep sea, where meetings between the two sexes are rare and infrequent. Males bite into the first female they meet because this represents a safer choice than hedging their bets with another female, who may never come along.

To find out how anglerfish achieve parabiosis, biologist Dr Thomas Boehm and colleagues from the Max Planck Institute of Immunobiology and Epigenetics in Germany examined the DNA of 31 anglerfish specimens from 10 species. They found that key immune system genes were missing from the anglerfish species in which males and females fuse. Somehow, they have compromised their immune systems to allow for parabiosis, without suffering ill effects. Understanding how anglerfish manage this trick could have significance for medicine, increasing the ease with which transfusions and organ transplantations can take place in future.

THEODORE W PIETSCH/UNIVERSITY OF WASHINGTON, JOHANNA WERMINGHAUSEN, HUW CORDEY/NATUREPL.COM

CAN'T GET YOU OUT OF MY HEAD
SEA SLUG

Earlier this year, scientists discovered a species of sea slug (*Siphopteron makisig*) that, in the throes of love, stabs its partner directly in the centre of its head with a venomous spur. Called the penile stylet, this spur (which is attached to the penis) injects a complex cocktail of hormones directly into its lover's brain, improving its odds of mating success. This is just one of many reproductive oddities to have evolved in sea slugs. Before transferring sperm, some sea slugs 'kiss' by grasping one another mouth-on-mouth. Sea slugs can also 'cuddle' after mating, coiling their colourful bodies around one another.

"It's likely that 'cuddling' may be more akin to mate guarding," says Cheyenne Tait, a seasoned sea slug observer at the University of Massachusetts Amherst. "The threat to their reproductive success is that their sperm is digested by their partner before it can be used for fertilisation. And so 'cuddling' allows sperm a chance to migrate deeper within the partner's reproductive tract."

Most people consider sea slugs, like many invertebrates, to be primitive inferiors of big-brained, bony animals. Their rich, duplicitous sex lives suggest otherwise.

→

BITE ME

REDBACK SPIDER

For male spiders, it's complicated. To prepare for sex, he first needs to ejaculate onto a tiny web and then collect his semen in a pair of syringe-like appendages near the mouth known as palps. Locked and loaded, the male spider must then approach a female, being careful not to activate her predatory kill reflex, and plug the palps into the female's reproductive passages, which happen to be mere millimetres from her venom-laden fangs.

To limit the chances of being eaten, male spiders have evolved complex dances to communicate their sexual intentions clearly. Others offer gifts to the female, to keep her entertained while the transfer of sperm takes place. But male redback spiders go one step further: while mating, the male balletically somersaults into the female's jaws, encouraging her to take a bite.

This self-sacrifice offers two bonuses to males. The first is that the longer she takes to snack, the more eggs his sperm can fertilise. The second is that females which have just eaten a male appear more likely to reject the next male that comes along.

ALAMY, ARDEA IMAGES

↑

CUPID'S ARROW

GARDEN SNAILS

During their courtship, some species of snail regularly fire chemical-tipped arrows at one another, just like the garden snails pictured here. And because snails have both female and male reproductive parts, these arrows (or 'love darts') often fly both ways.

"The aim of love darts is not to kill the mating partner, but to introduce bioactive substances that influence the reproductive processes of the mating partner," says Dr Joris M Koene, an expert in snails based at the Amsterdam Institute for Life and Environment.

The substances found on love darts include a rich cocktail of special compounds (known as allomones) that stop sperm from wasting away in the reproductive tract of a potential mating partner, should mating occur.

Each snail species has its own unique shape of dart. Some love darts are curved like harpoons. Some are barbed. Some even have diamond-shaped tips, like ornate spears.

Do they ever misfire and cause death?

"I have seen an occasional dart shooting that resulted in the dart going straight through the head of the recipient, but even in those cases the recipient survived," Koene says.

↑

PLEASED TO EAT YOU

PRAYING MANTIS

"Cannibalism has its benefits," says Nathan Burke, a postdoctoral research fellow at the University of Hamburg, who studies mantis mating strategies. "It can lead to improved growth, condition and reproduction for the cannibal. What separates many mantises and spiders from other cannibalistic animals is that they also cannibalise in a mating context, and typically it's only the female that eats the male."

Burke is especially interested in the wrestling matches that some mantis species go through before mating, which involve intense grappling and violent tussles between males and females, using their raking forelegs. Should a female win these struggles, the male almost certainly ends up eaten. But if a male wins, he stands a good chance of mating. Quite why sexual cannibalism is so rare among insects remains a subject of debate.

"The thing about mantises is that they're mostly sit-and-wait predators. Rather than move around looking for food, they wait patiently for their food to come to them," says Burke. "It's possible that this sit-and-wait lifestyle is a pre-adaptation for sexual cannibalism."

This may explain why cannibalism occurs in other sit-and-wait predators, such as spiders.

→

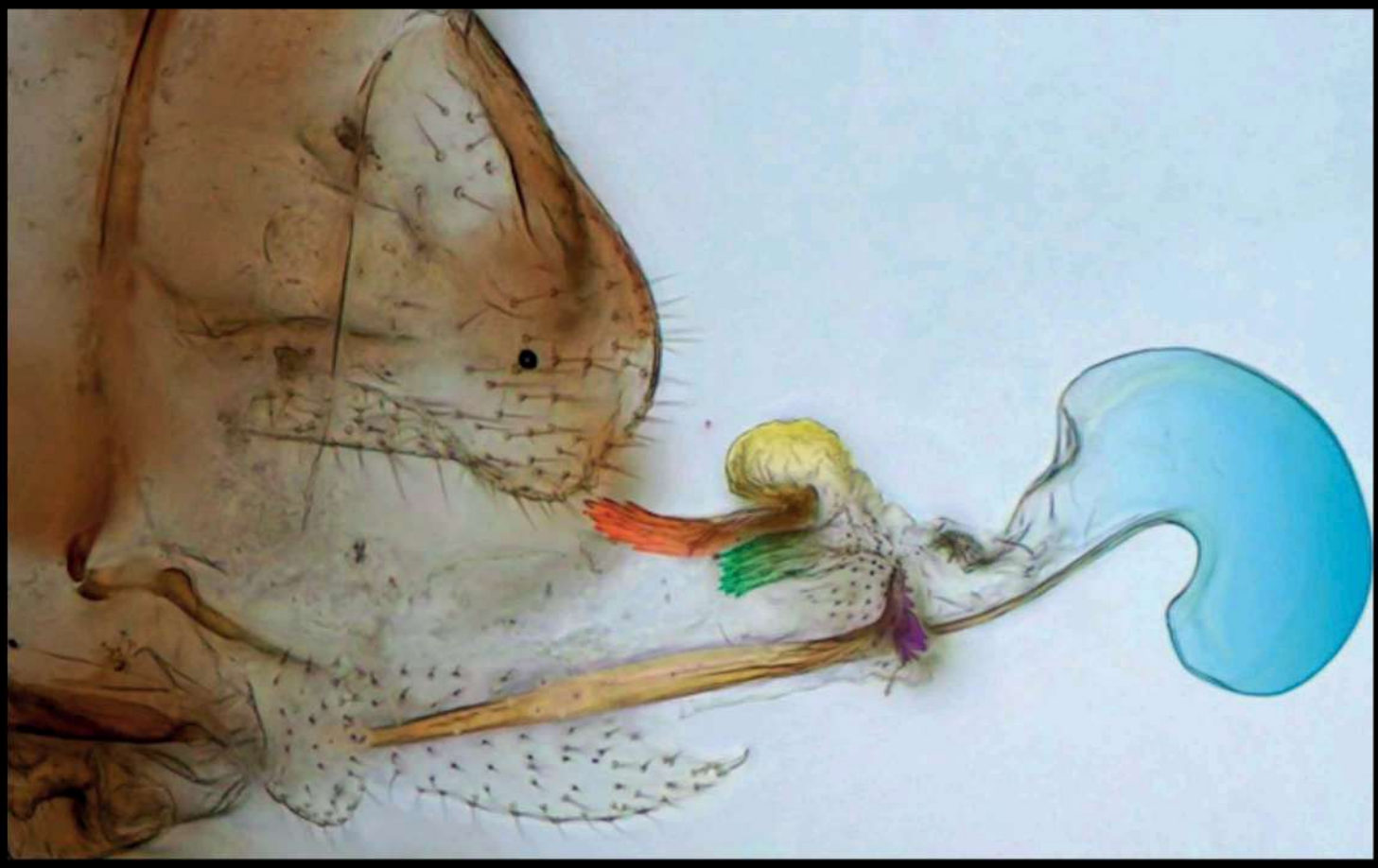
GIANT GENITALS

FEMALE BARK LICE

This is not a penis. It is an engorged bark louse vagina that can be thrust into males like a hoover attachment, to gather up sperm. The first discovery of this penis-like vagina (seen here in blue) came in 2014, from a single cave-dwelling bark louse species in Brazil. The second penis-like vagina, announced in 2019, was also in a species of bark louse, this time from a cave in Africa.

What caused the same adaptation to arise separately in two species? One theory is that the ancient ancestor of both bark louse species hit upon a form of reproductive 'plumbing' which accidentally unlocked a mechanism for extending the vagina outwards. Another reason is that both species live in societies where gift-giving by males, in the form of nutritious sperm, is common. As caves are often lacking in nutrients, the hypothesis is that females evolved extendable vaginas to get food as well as to procreate. They can absorb the sperm once they've gathered it, making it a nutrient-packed snack.

"These factors made female competition for the nutritious semen more intense, which we think facilitated the origin of the female penis," says entomologist Kazunori Yoshizawa of Hokkaido University in Japan, who was part of the team that first discovered this spectacular arrangement.



PAUL HARDCOURT DAVIES/NATUREPL.COM, JOHANNA RONN/UPPSALA UNIVERSITY, K YOSHIZAWA

PRICKLY PENIS

SEED BEETLE

Laced with hundreds of sharp spines whose purpose is to scratch and tear the female's genital tract, the penis of the seed beetle makes no sense at all. After all, how could genes for a penis that injures the female's reproductive tract spread throughout a population?

For male seed beetles, the perks of a prickly penis are clear: males with longer spines tend to produce more offspring, partly because the wounds the male inflicts act as an entry point for a cocktail of nutrient-rich chemicals he produces during sex. But in genetic terms, females can also benefit. In 2021, Swedish scientists bred two lines of male seed beetles, one with long spines and the other with short. They then watched what happened to the females that bred with each sub-group.

The female seed beetles that mated with the males with long-spined penises, had sons with the same long spines. But their daughters also appeared to inherit some valuable traits. On average, they had larger bodies and laid more eggs in their lifetime. **SF**

by **JULES HOWARD** *(@juleslhoward)*
Jules is a wildlife expert and zoology writer. His latest book, Wonderdog *(£17.99, Bloomsbury Sigma), is out now.*

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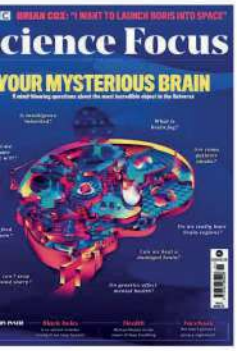

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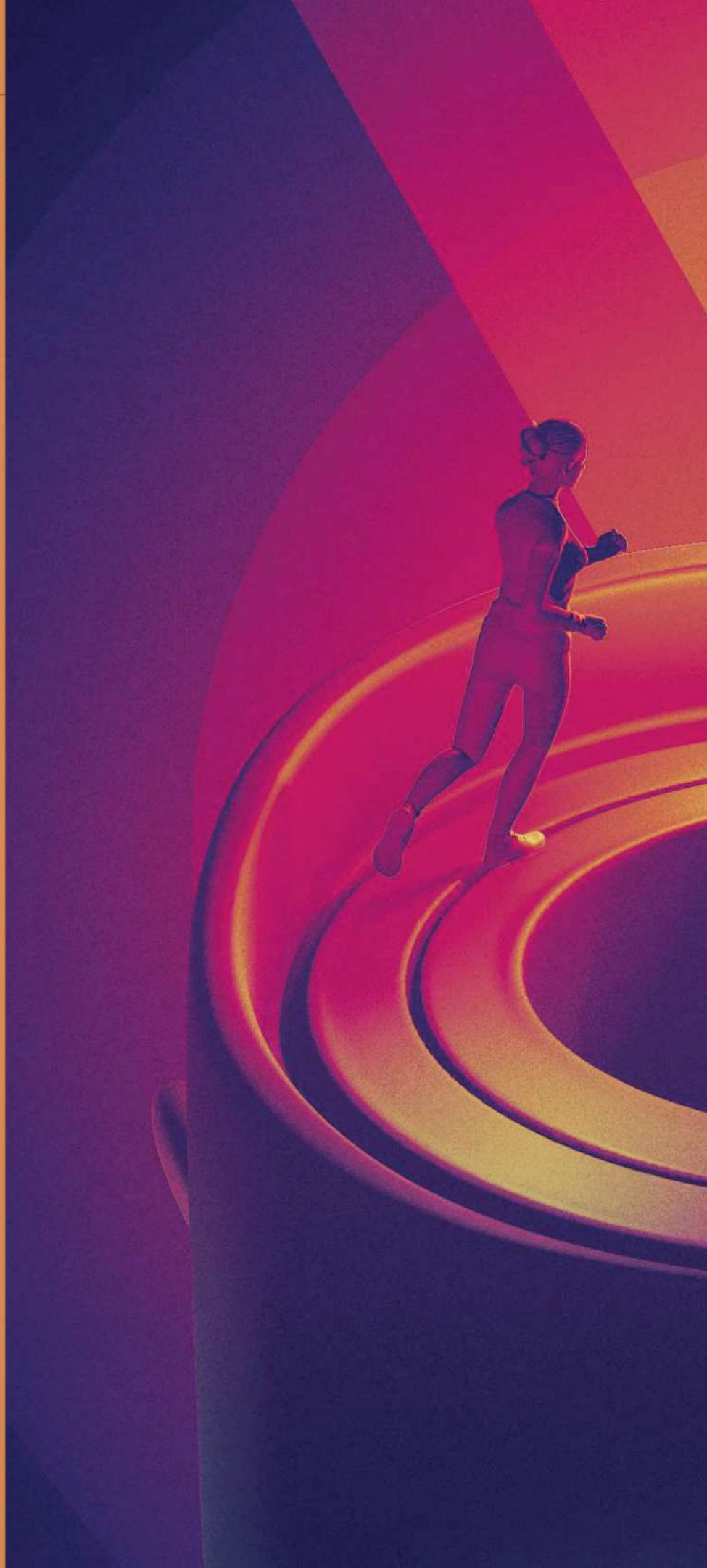
EVERYTHING YOU EVER WANTED TO KNOW ABOUT THE MULTIVERSE

OBSESSION

Why there are some ideas our brains can't shake

by HELEN GLENNY



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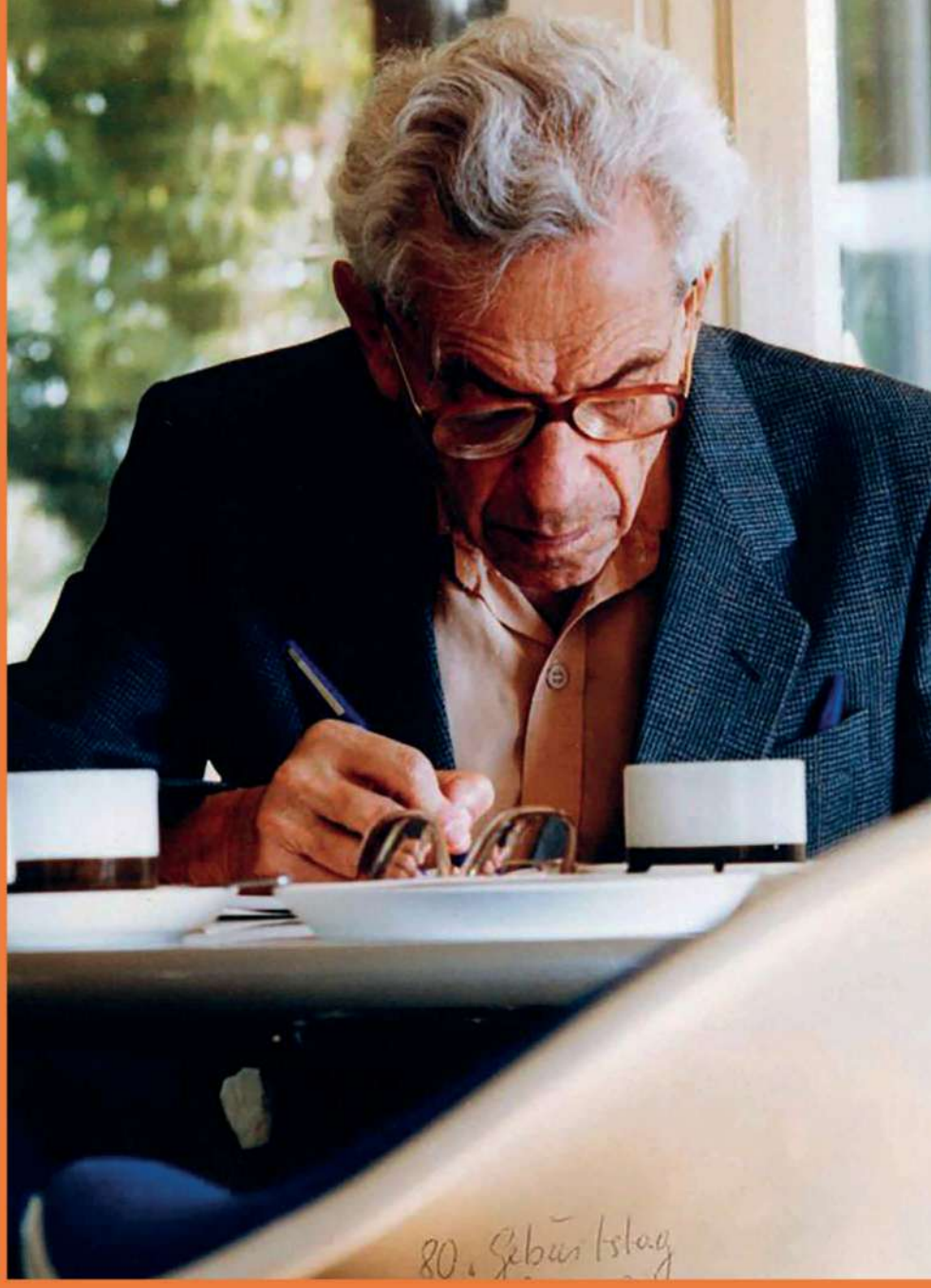


Paul Erdős was a strange houseguest. The brilliant mathematician, born in 1913 in Austria-Hungary, would show up on friends' doorsteps with a fraying suitcase and an orange bag from a department store in Budapest. Not only would he expect them to do his laundry, but he would wake them in the early hours of the morning, looking for a mathematical collaborator. He would declare "my brain is open", while asking if theirs was the same.

Erdős spoke a language that reflected his obsession with maths. If someone left the field, they'd "died", while if someone actually died, they'd merely "left". He exclaimed that prime numbers were his "best friends". He published more papers than any other mathematician in history, but spurned full-time job offers, instead living for 50 years as a nomad. He went from one collaborator's house to another, looking for those whose brains were open. His obsession with numbers, theorems and mathematical problems made Erdős one of the most beloved and respected people in the field of maths, despite overstaying his welcome in a lot of people's homes.

While obsessions as extreme as Erdős's may be rare, they are a hallmark of human existence. They can drive us, help us accomplish goals, develop skills and amass knowledge. Pop culture tells us obsession is a good thing. Books like the entrepreneur Grant Cardone's *Be Obsessed Or Be Average* sit on self-help shelves in bookshops.

"We have this category of obsession that's related to genius and talent, to sports and perfection. We live in a society that is devoted to it, where we're supposed to be obsessed," says Lennard Davis, an English professor at the University of Illinois.

Harmless obsessions see us learn everything about a favourite band or celebrity. But some of us fall victim to obsessions that become harmful. For example, when a celebrity obsession turns into stalking, or when a concern about fire leads us to ritually check the oven many times before leaving the house.

So what is it about the human brain that means an idea can shift from a thought to an obsession, and is there a difference between those obsessions that society deems healthy and those it considers not?

DOPAMINE HIT

Dopamine is one of the brain's neurotransmitters, a chemical messenger that relays signals between neurons and brain areas. It's mostly linked to a sense of reward and pleasure, conveying the message that this is behaviour worth repeating, though this is just one of many of its functions. Typically, a dopamine surge follows success, regardless of whether that's in sport, work, or a video game. Dopamine isn't the only neurotransmitter in the reward pathway, but it is the key neurotransmitter involved in *wanting* the reward,

RIGHT Stamp-collecting can be a healthy or unhealthy obsession

LEFT Famed mathematician Paul Erdős would wake in the early morning to work on his maths theories, and expect his hosts to join him

and therefore motivating people to pursue it. Our expectation of a reward could be cued by loading up a web page to check stock performances, getting a notification from work, or thinking about ticking a workout off our exercise schedule. But every time pleasurable activities are experienced, powerful self-regulating mechanisms kick in to bring dopamine levels back down again. Dopamine boosts are strongest from novel activities (the first time you try a new type of a food, for example), and consequent hits are never as rewarding because of the way your body and brain regulate the presence of the neurotransmitter. Therefore, most pleasurable activities don't escalate to obsessions, because they produce small enough dopamine spikes that we enjoy them and then decide to pursue something new in order to experience the boost again.

However, if we repeat the exposure to the thing that gives us pleasure, the self-regulatory mechanisms that make us feel low afterwards can get stronger and last longer. Then, "we need more exposure to our drug of choice to get the same effect", writes psychiatrist Prof Anna Lembke in her book *Dopamine Nation*. This is called neuroadaptation, and it's how we create tolerance to certain stimulants. For a chocoholic, one bar doesn't do it anymore. A workaholic pursues longer hours.

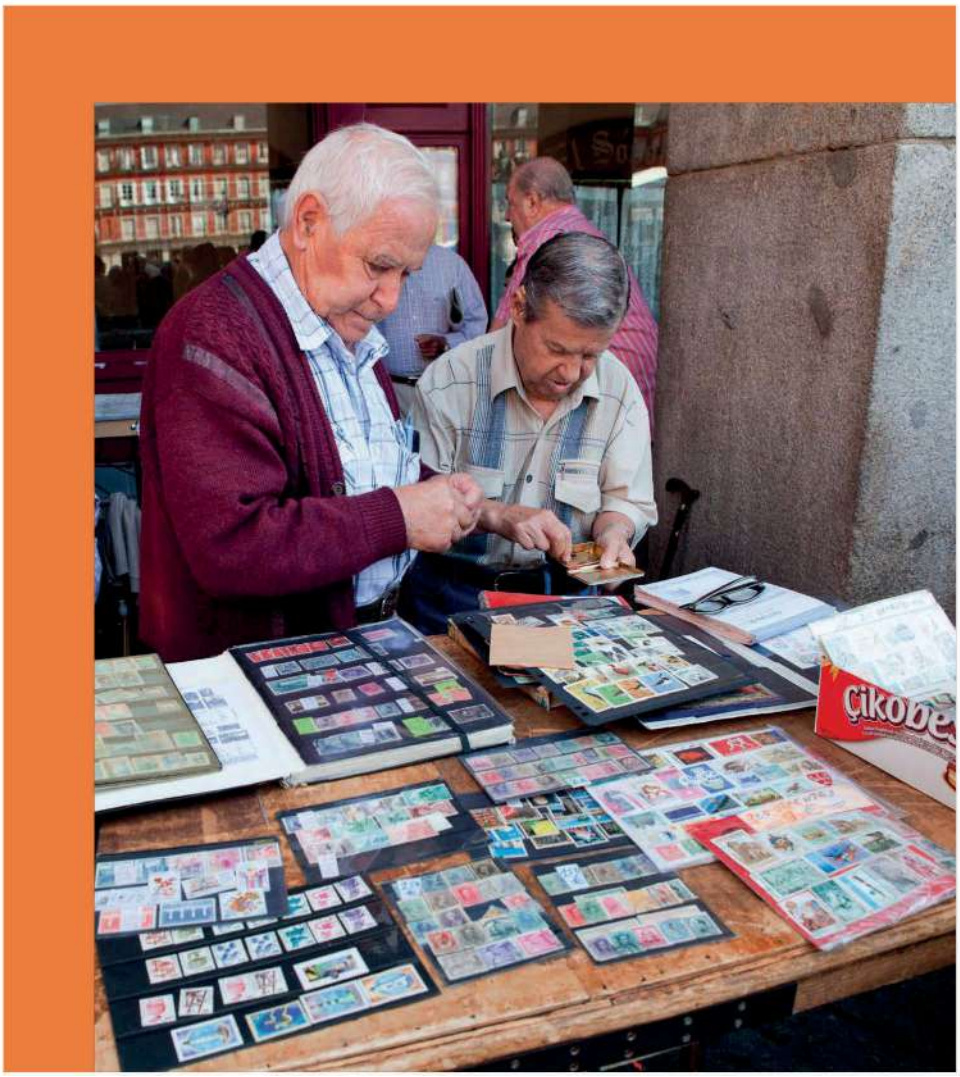
FROM OBSESSION TO ADDICTION

Sometimes, obsessions can become addictions. Addiction is defined by a continued or compulsive pursuit of a substance or behaviour, despite its harm to oneself or others. For a long time, the term 'addiction' was only used to describe harmful use of substances like nicotine and amphetamines. But more recently, the definition has been expanded to behavioural addictions. Gambling addictions are common, but addictions to exercise, work, and even shopping are now acknowledged.

While there are numerous studies that have found that environmental factors can increase a person's risk of addiction, there is a growing body of evidence suggesting that some of us are more prone to addiction than others, thanks to our genes.

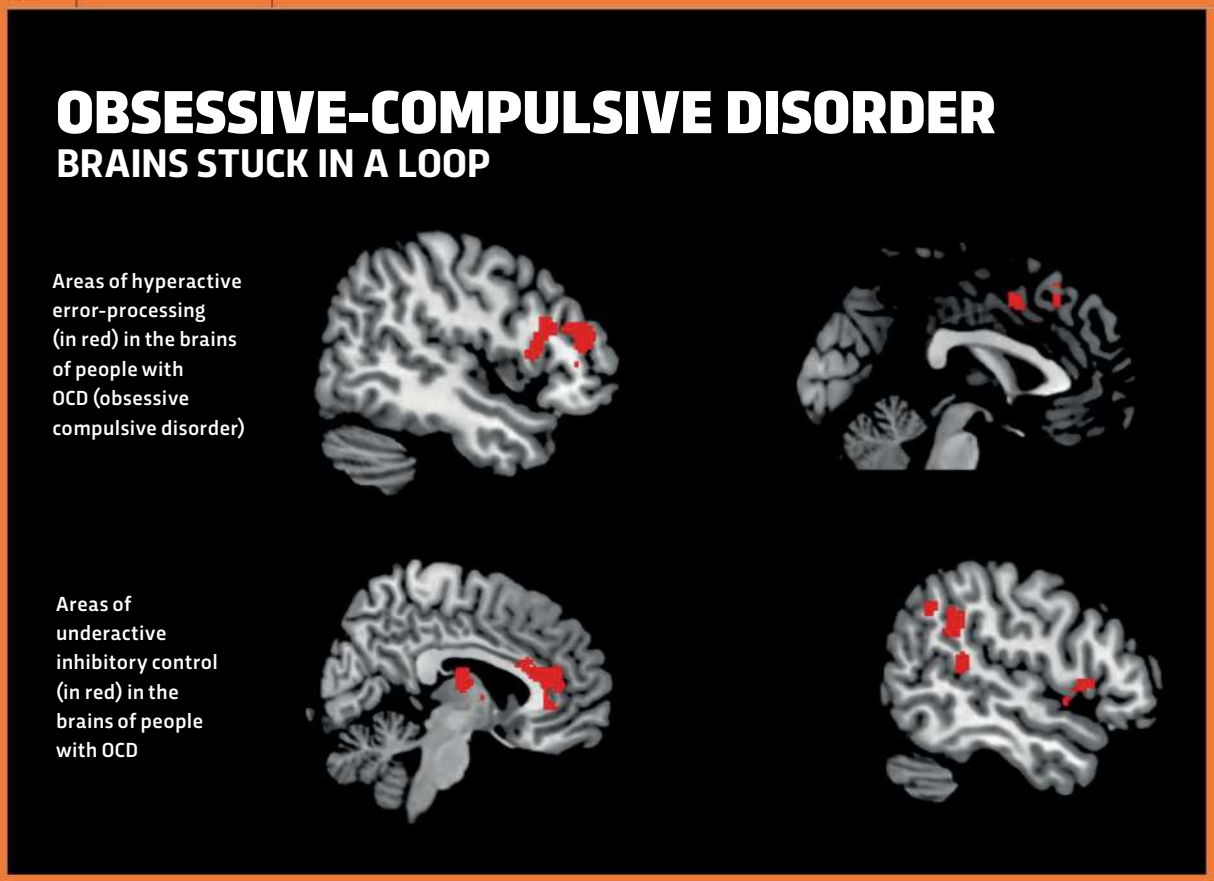
Back in 1996, the US scientist Dr Kenneth Blum coined the term 'reward deficiency syndrome', where some people inherit a genetic variation that affects the 'brain reward cascade'. While most of us experience dopamine spikes in response to fairly mundane pleasures of everyday life, people with this genetic variation don't get as much of a hit from these activities, so are more prone to seek ever-greater highs through drugs, alcohol, food and high-adrenaline sports. Blum estimated that up to 30 per →

"SOME OF US ARE MORE PRONE TO ADDICTION THAN OTHERS, THANKS TO OUR GENES"



GABRIELLA BOLLOBAS, ALAMY

OBSESSIVE-COMPULSIVE DISORDER
BRAINS STUCK IN A LOOP



Areas of hyperactive error-processing (in red) in the brains of people with OCD (obsessive compulsive disorder)

Areas of underactive inhibitory control (in red) in the brains of people with OCD

UNIVERSITY OF MICHIGAN, GETTY IMAGES

"STUDIES OF ENDURANCE RUNNERS HAVE SHOWN THAT WITHDRAWAL SYMPTOMS CAN DEVELOP AFTER 24 TO 36 HOURS OF NOT RUNNING"

ABOVE A Michigan University study compared the brains of people with OCD and healthy volunteers

OPPOSITE Fandom for famous musicians and actors (like Timothée Chalamet, pictured here) can range from mildly obsessive to borderline pathological worship

→ cent of the population may have these underactive reward pathways.

While trying to reach a new level in *Minecraft* might cause your friends to say you're obsessed, few would question the hours Michael Phelps spent in the pool to achieve Olympic stardom. But even his obsession may have been mediated by the same pathways as less-productive obsessions. Exercise produces dopamine spikes like other pleasurable activities, and studies of endurance runners have shown that withdrawal symptoms can develop after 24 to 36 hours of not running, producing irritability, anxiety and guilt. "Obsession is socially constrained," points out psychiatrist Prof Dean McKay.

One determinant of whether your obsession is healthy depends on how valued the obsession is. "Someone could be obsessed with stamps in a way that's unhelpful. On the other hand, being a philatelist is actually a career where you might look for ways to trade and sell valuable stamps in a collector's market, the way someone might with art," he says. "The other factor is the degree to which the pursuit of an obsession causes personal distress," says McKay.

STUCK IN A LOOP

In the psychological and mental health realm, obsession is where someone is plagued by intrusive thoughts that they can't eliminate. "There is a strong desire not to experience that thought. In a way, it's the exact opposite of a passion. The person is haunted by their obsession," says McKay.

When people become so obsessed with a thought that it causes anxiety or compulsions, it can begin to veer into obsessive-compulsive disorder (OCD).

"Let's say on average, people want to be clean," says McKay. "If you ask 100 people if →

OBSESSED WITH THE STARS

Tabloids and social media have given rise to one of our most common and pervasive obsessions: celebrities

Obsessions with celebrities are measured using the Celebrity Worship Scale, which was devised by psychologists in 2002 and published in the *British Journal Of Psychology*. For most people, relationships with celebrities are what sociologists term 'entertainment social', where an attachment to a celebrity provides entertainment or enhances social activities. They will agree with statements like 'I love to talk with others who admire my favourite celebrity'.

Mild obsessive qualities can start to come in when these relationships become 'intense-personal' ('When something good happens to my favourite celebrity, I feel like it happened to me').

An extreme form is called 'borderline-pathological' ('If I was lucky enough to meet my favourite celebrity, and they asked me to do something illegal as a favour, I would probably do it').

Celebrity worship is fairly new to academia, so not much is known about how these relationships affect our brains. A 2021 meta-analysis of studies about celebrity worship showed that intense-personal and borderline-pathological celebrity worship are correlated with neuroticism and psychotic tendencies, and appear to be related to poorer mental health. It is also linked to poor-quality intimate relationships and a difficulty coping with conflicts, though whether intense Taylor Swift fandom or Nickelback devotion causes these difficulties – or stems from them – is yet to be determined...

ALAMY

"IN RARE CASES, PEOPLE DEVELOP OCD AFTER HEAD TRAUMA, OR IN RESPONSE TO INFECTIONS AND ENCEPHALITIS, ADDING WEIGHT TO THE IDEA THAT CHANGES IN THE BRAIN CAN CAUSE OCD"

→ they'd prefer their hands to be clean before they eat, the majority of them are going to say yes. And there are going to be some people who really make sure of it, which is still in the range of, shall we say, normal." But a few of those people may experience some life stressor, usually something run-of-the-mill and not particularly traumatic. "Then they'll push cleanliness to a level where it will start to be harmful, where the washing becomes very excessive, and it leads to problems in other areas of their life," McKay says. This is where it becomes OCD.

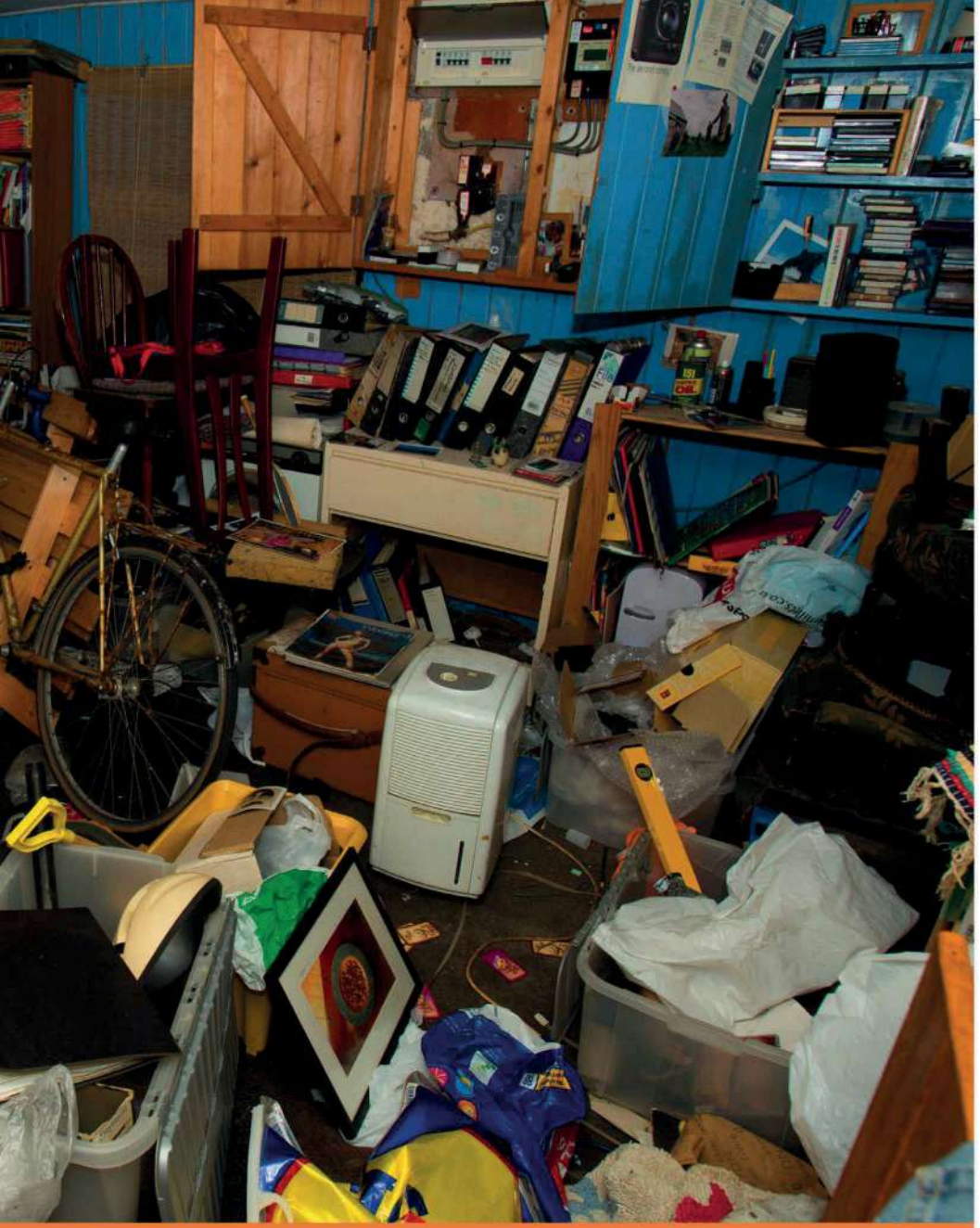
The social factors around taboo topics strongly affect patterns of OCD. "A society may have greater prohibitions about certain behaviours, so you see a corresponding increase in obsessions related to them," McKay says. "One that has received a lot of publicity lately is intrusive thoughts about paedophilia. Many people with OCD will have these thoughts – 'I saw a child, it occurred to me that the child was good looking'. When that thought shows up, the person might say, 'wait a second, why did I think that? Am I attracted to children?'

"That person is in no way attracted to children – they have no desire, no interest, nothing. But they get that thought, and now suddenly they're anxious about it. Now they're avoiding that thought and when it shows up they get more anxious, and that makes the thought more prevalent," he says.

Usually, OCD involves compulsions. Sometimes they're related to the intrusive thought, like someone who ruminates over germs may wash their hands many times a day. Sometimes they're unrelated, like a child who needs to have his shoes lined up perfectly in order to protect his parents from harm. But in rare cases, OCD can be absent from visible compulsions, and this is where the term 'Pure O' arises.

"It's a useful term because there are taboo thoughts and intrusive ideas that have no clear external ritual that might alleviate them," McKay says. But psychiatrists don't tend to use the term, because Pure O sufferers *do* change their behaviour.

"There are things in the environment that might activate a thought, so sufferers of Pure O might go to great lengths to avoid them. For example, they may get this thought: 'I'm near a steak knife, and I don't know what might happen'. So they might engage in behaviour where they make sure there are no sharp objects around."



ABOVE Hoarding has been removed from the diagnostic criteria for OCD

There isn't an easily definable behaviour, so it presents like a pure obsession. Another way people with Pure O act on their intrusive thoughts is to counter them with other thoughts, to seek reassurance. One common OCD 'theme' is sexual orientation obsession, in which sufferers obsess over whether they have a different sexual orientation than the one their current relationship is based on. If they find someone of the same sex attractive, they might feel compelled to spend time thinking of attractive people of the opposite sex, in order to reassure themselves.

Neurobiological and neuroimaging studies give us some clues as to how OCD plays out in the brain. In functional MRI studies, people with OCD tend to have more activity in the brain's corticostriatal pathway, which controls movement execution, habit formation and reward.

In rare cases, people develop OCD after head trauma, or in response to infections and encephalitis, adding weight to the idea that changes in the brain can cause OCD. It's also expected that serotonin plays a role in OCD, because selective serotonin reuptake inhibitors (SSRIs) are effective for some people who suffer from OCD.

But researchers still don't have the full picture about OCD. "I don't think we've defined OCD in a way that will permit us to identify the biological base," says McKay. "Contamination, for example, stands apart because it's not just anxiety – it also relates to disgust, which involves an entirely different emotional system."

Hoarding was also once considered a subtype of OCD, so people with hoarding tendencies may have been included in OCD MRI studies, but recently it's been removed from the diagnostic criteria for OCD. Without an accurate picture of what OCD is exactly, it's hard to get a good idea of what's happening in the brain.

CAN YOU TREAT OCD?

So what treatments are on offer for people with OCD? Sufferers may be offered a course of SSRIs, and cognitive behavioural therapy (CBT). In some cases these don't work, and more invasive treatments like deep brain stimulation are trialled, where electric impulses are passed through electrodes implanted into particular brain areas.

McKay has some tips, if intrusive thoughts begin to recur in our minds. "Remind yourself that a thought is just a thought, it doesn't necessarily mean anything," he says. Psychiatrists talk to their patients about 'the over-importance of thoughts', which is an attitude where people assume that if they thought something, it must be meaningful. "But the truth is that people just have random thoughts," says McKay.

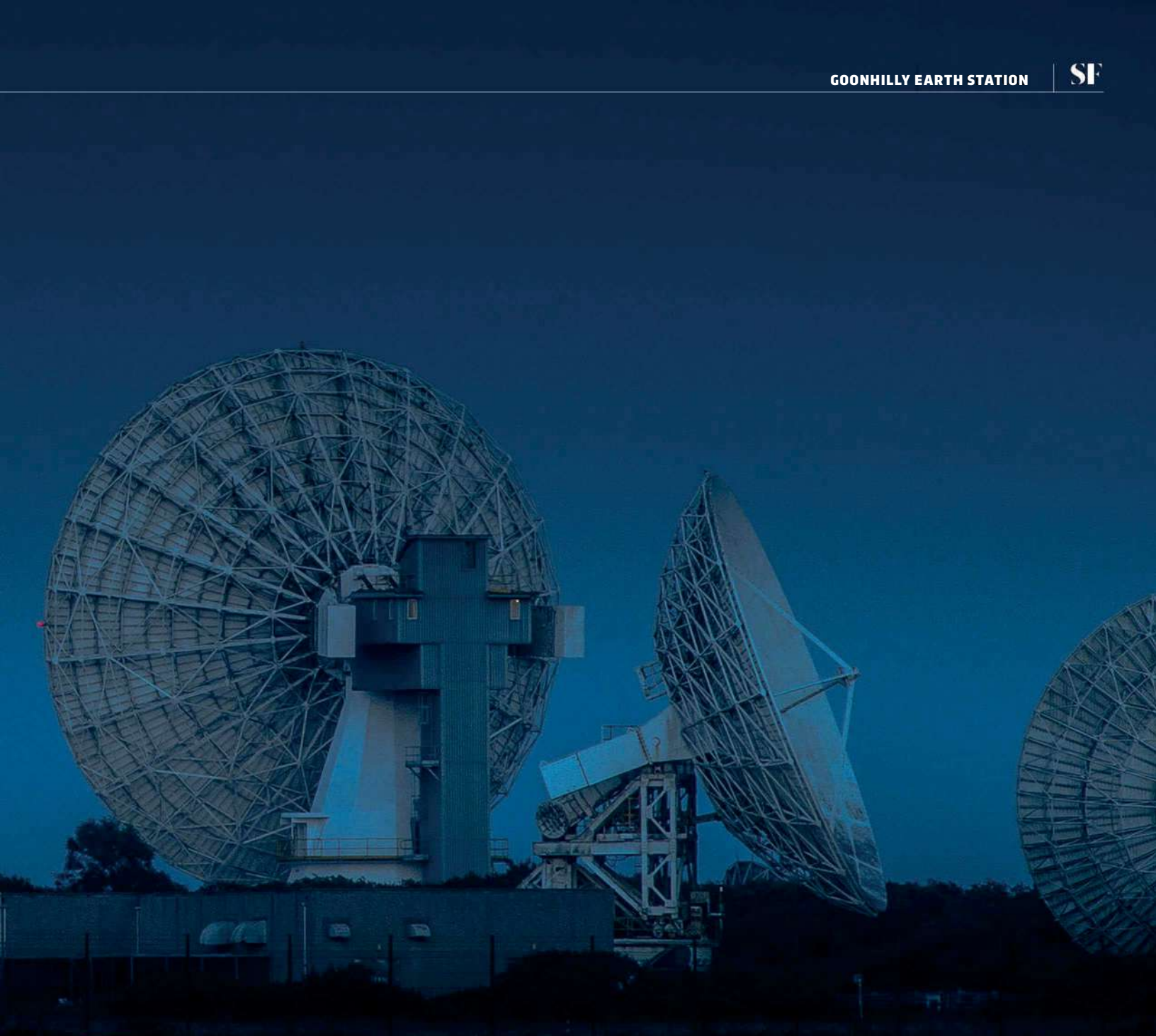
He also suggests keeping in mind that we will always live our lives with some measure of uncertainty. Whether you obsess about making sure your hands are clean, or about proving a complicated mathematical theory, we can only be mostly certain. "The more that people get comfortable with that, the more likely they are to free themselves from harmful obsessions." **SF**

by HELEN GLENNY
(@hcglenny)
Helen is a freelance science writer, with a background in neuroscience and physiology.

by DR STUART CLARK

GOONHILLY: TO INFINITY AND BEYOND

IN NOVEMBER 2022, GOONHILLY MADE HISTORY AS IT TRACKED NASA'S ARTEMIS 1 MISSION TO THE MOON. BUT THAT'S NOT THE END OF THE STORY. THE LITTLE-KNOWN STATION, NESTLED IN THE TOE-TIP OF ENGLAND, IS POISED TO BECOME THE UK'S WINDOW TO THE NEXT ERA OF SPACE EXPLORATION



ALAMY

On the same day that Apollo 11 landed on the Moon 50 years previously, a lunar eclipse is seen over Goonhilly Earth Station

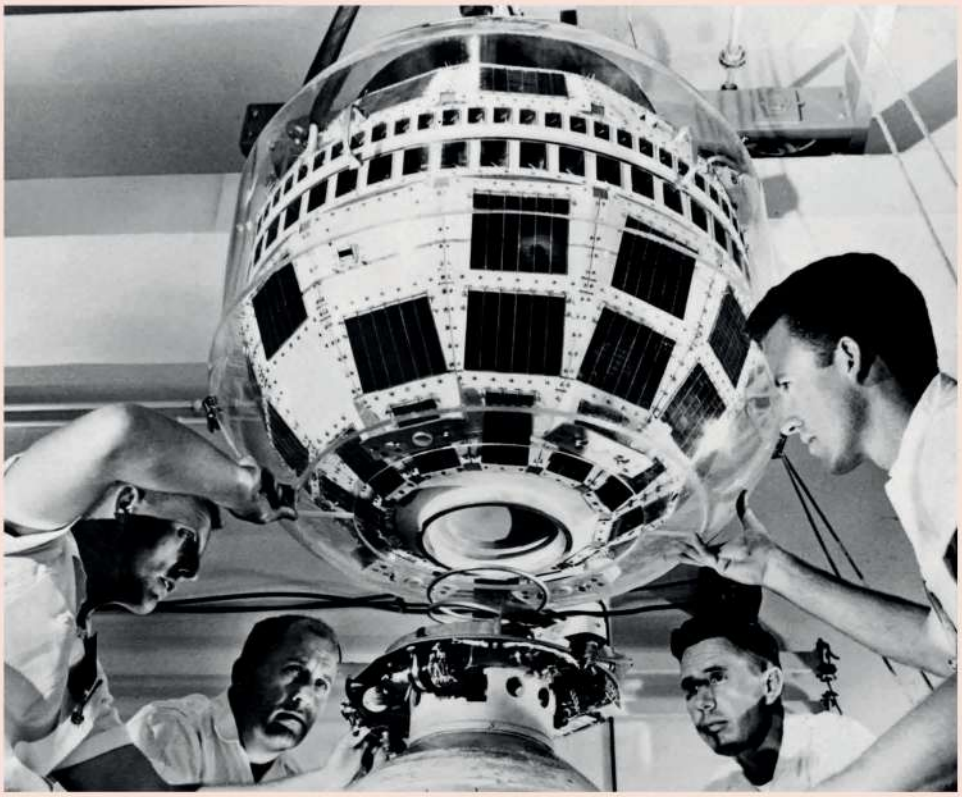
The 11 July 1962 should be remembered as the day the world got smaller. Not literally, of course, but metaphorically; it was the day of the first transatlantic satellite communication between Britain and the United States of America.

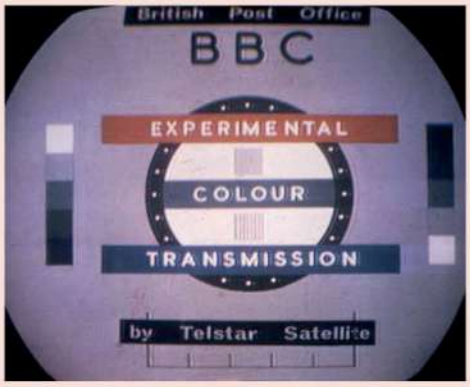
Racing through the skies, approximately 950km overhead, was the world's first commercial communications satellite. Telstar 1 had been launched the day before from Cape Canaveral in Florida. The size of a large beach ball, the satellite was the thin end of a technological wedge because an international consortium of companies had built a string of antenna stations around the globe to receive and transmit the signal. The stations were in the US, Canada, France, Germany, Italy and the UK.

The UK's station was on Goonhilly Downs, on the Lizard Peninsula in Cornwall. This windswept plain was chosen because it looked out over the Atlantic. Its excellent view of the sky to the west meant that it could see satellites for longer than other inland locations. And the receiver that the General Post Office (GPO) built there was as large as Telstar was small.

Known as Goonhilly 1 (GHY-1) but nicknamed 'Arthur', the dish antenna was almost 26 metres wide and the entire structure weighed 1,100 tonnes. On 11 July, it started tracking Telstar as the satellite came across the western horizon heading east. Taking just two hours and 37 minutes to circumnavigate the globe, the satellite had been placed in an elliptical orbit so it spent as long as possible over the Atlantic.

Even so, only around half an hour of transmission time was possible before it disappeared from the skies, and that meant the giant GHY-1 antenna had to follow Telstar precisely, even when it was moving





at around three times the apparent diameter of the full Moon every second.

Just one day after launch, Telstar was on its 15th orbit of Earth, when it beamed pictures from the US down to GHY-1. On its next orbit, Goonhilly transmitted a live television broadcast from its control room, featuring BBC commentator Raymond Baxter and Captain CF Booth, deputy engineer-in-chief of the GPO.

MAKING HISTORY

During the following days and weeks, increasingly complex signals were traded between Telstar and Goonhilly, including the first fax transmission of a picture and the first colour television images. But it was something even more historic that captured Goonhilly's current CEO Ian Jones's attention.

Apollo 11 landed on the Moon in 1969 and GHY-1 helped receive the television pictures of astronauts Neil Armstrong and Buzz Aldrin walking on the lunar surface. "Being a child of the 60s, space and Apollo were the exciting, inspirational things, and I can't remember not knowing the name Goonhilly. It's a key part of the UK's history," he says.

Throughout its ownership by the GPO, which later became British Telecom (BT), the station developed into a hub for global telecommunications, adding more antennas along the way. The largest of these is

ABOVE NASA technicians assemble the Telstar 1 satellite ahead of its launch in July 1962

TOP RIGHT The BBC Test Pattern was one of the early TV signals broadcast from Goonhilly to test the Telstar system

ABOVE RIGHT Among the signals from Goonhilly relayed to the US via Telstar was a woman peeling fruit

AI IN SPACE

Goonhilly is pioneering a Space Artificial Intelligence Institute. Satellites are now capable of producing so much data that just sorting through it, let alone analysing it in a reasonable time, is stretching human capacity to the limit.

To remain close to the concept of real-time data, analysis will require machine learning and artificial intelligence – computers capable of interpreting those signals collected by satellites and space missions in real time, just like our brain does with the things we sense.

Goonhilly space scientist Olivia Smedley has been investigating the use of AI techniques on satellite data, to map trees across Cornwall. She sees a strong crossover with the traditional work of the Earth Station. "There are a lot of parallels between the mathematics used for digital signal processing, and the kind needed for how AI works. So it's an interesting avenue to be exploring," she says.

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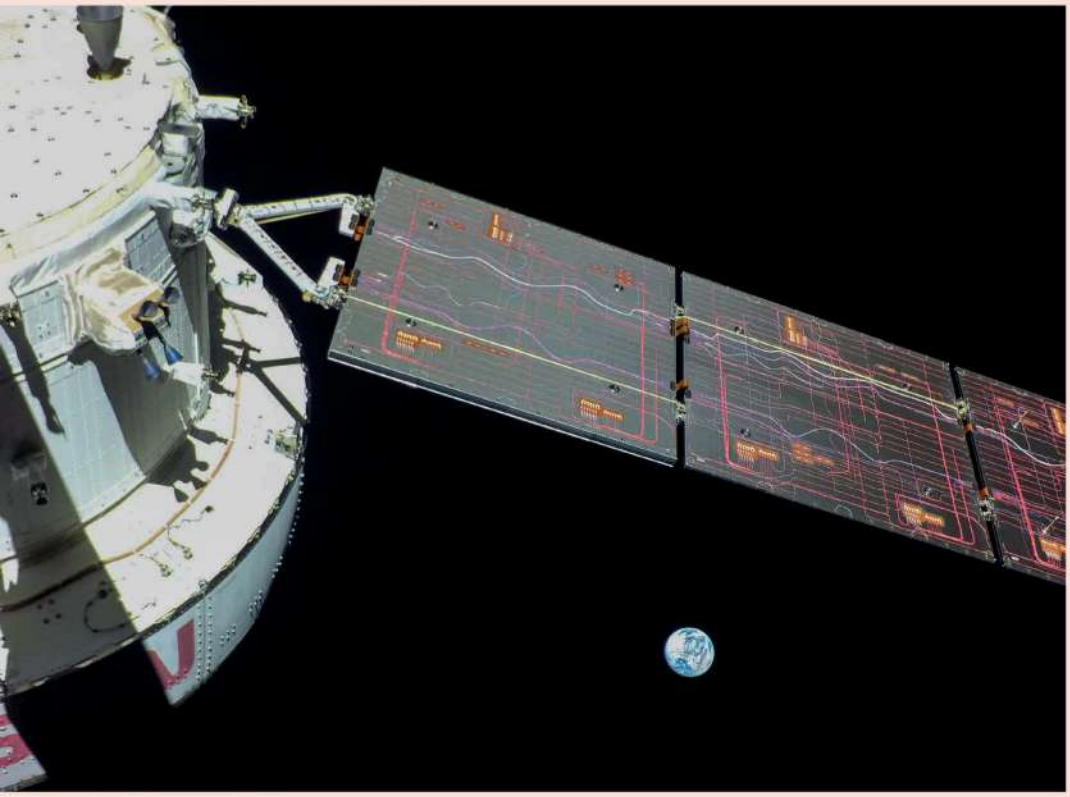


ABOVE The Orion capsule's recent journey to the Moon was tracked by the Goonhilly Earth Station

the 32-metre Goonhilly 6 (GHY-6) dish, also known as Merlin. Completed in 1985, its first job was to relay the famous Live Aid concert to 100 countries across the world. It even earned a *Blue Peter* badge that same year, although, sadly, the weather has taken its toll on the badge's plaque.

But in the decades that followed, the world changed. The cost of owning and operating satellites began to fall, and companies like Sky TV were pioneering satellite-to-home transmission, with consumers needing just a small dish on their homes to receive the signals from space. As a result, a huge satellite station like Goonhilly began to look like an expensive relic from a bygone age. BT closed the station in 2008, and a few years later scheduled it for demolition.

A NEW LEASE OF LIFE

That was the catalyst for Jones. He realised that, just as Goonhilly had been used to pioneer satellite-based broadcasting, there could be a new role for it pioneering commercial deep-space communications. In 2014, he assembled a team to explore that possibility, set up a company called Goonhilly Earth Station Ltd (GES), negotiated with BT to take over the site and lease the antennas, and turned Goonhilly into the world's first privately owned deep-space communications network.

"Communications is one of those things that quite often gets forgotten," says Jones, pointing out that as more spacecraft are being built, and as more spacecraft are surviving for longer in space, there's often a logjam of missions wanting to communicate with Earth. This results in the traditional deep-space networks built by NASA and ESA being heavily over-subscribed. Add to that the private companies entering the launch market and the need for more ground stations becomes obvious.

GES worked with ESA and NASA to convert GHY-6 into a deep-space antenna capable of receiving data from their spacecraft and transmitting commands to them. Now, GHY-6 routinely communicates with the ESA missions Gaia, Integral, Cluster and Mars Express.

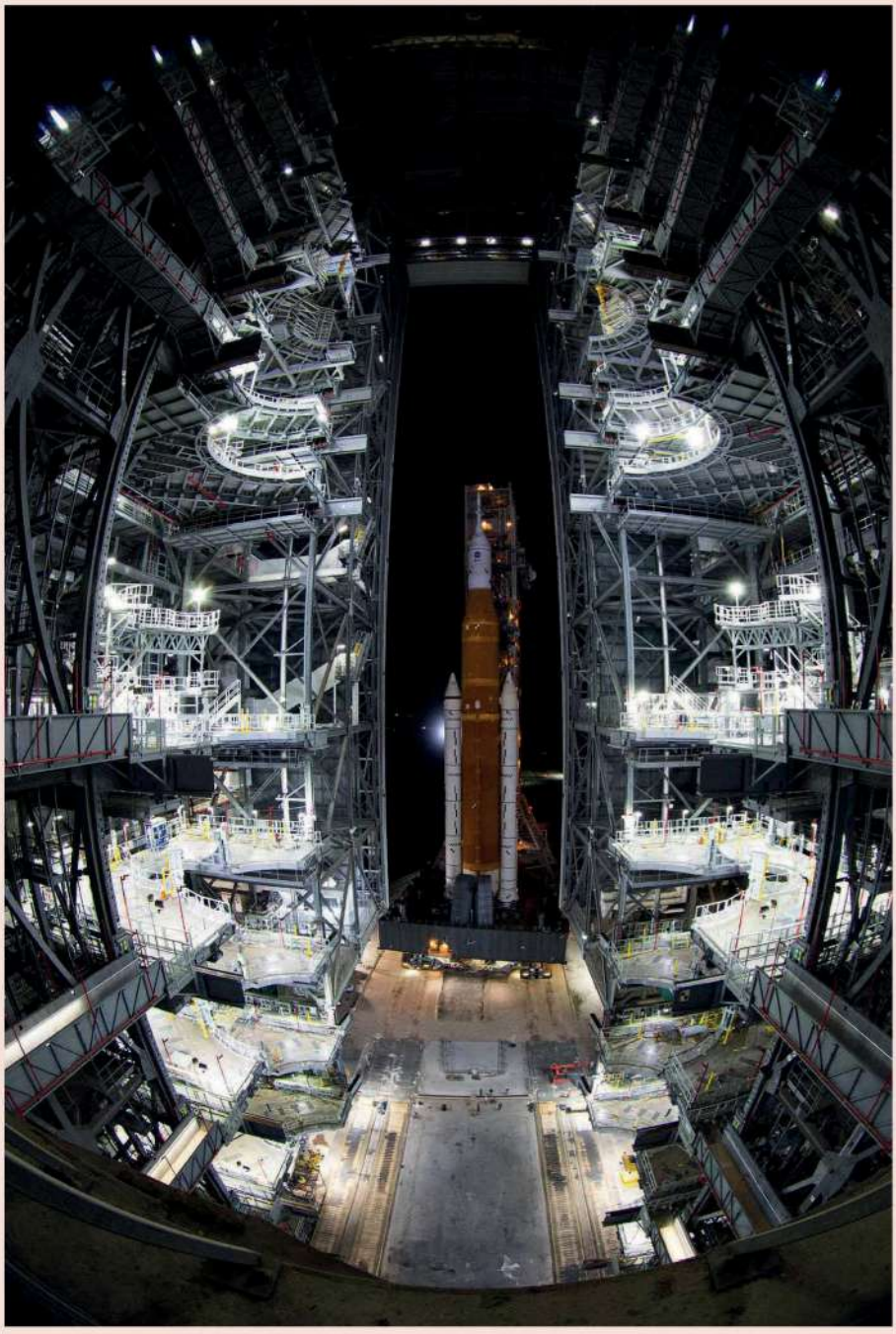
"It's been super exciting to actually be downlinking signals from Mars Express," says Goonhilly space scientist Olivia Smedley, who was part of the team that worked to upgrade the antenna. "Seeing images of Mars that have come through the dish here at Goonhilly is cool." ➊

"GOONHILLY-6'S FIRST JOB WAS TO RELAY THE LIVE AID CONCERT AROUND THE WORLD"

GOONHILLY: WHAT'S THERE?

The Goonhilly Earth Station covers a 160-acre site and features around 40 antennas. Most are smaller, five-metre-class dishes. Not all of Goonhilly's large antennas have survived over the years, but three still exist. Of these, the original Goonhilly 1 (GHY-1) is now largely retired. GHY-6 is a dedicated deep-space communications antenna, capable of sending and receiving information to and from distant spacecraft. Meanwhile, GHY-3 is a radio telescope that can also be used for detecting radar signals reflected back off pieces of space junk.

"IT WAS VERY EXCITING TO SEE THE SIGNALS FROM ORION ONLY A FEW HOURS AFTER IT LAUNCHED"



ABOVE Artemis 1 marked the start of a new phase of the collaboration between NASA and Goonhilly

RIGHT Goonhilly's Olivia Smedley watches live signals arrive from NASA's Perseverance rover on Mars

TOP RIGHT Virgin Orbit is one of the private companies whose launches Goonhilly will track

In the summer of 2022, NASA asked GES for its help in tracking Artemis 1. This mission is the first uncrewed test of the Orion space capsule that will be used to help return astronauts to the Moon.

Smedley and colleagues started well before dawn on Orion's launch day to set up GHY6 with the correct frequencies and data rates to be ready for whenever the Americans pressed 'go'. "It was very exciting to see the signals from Orion only a few hours after it launched," she says. One of the jobs for GES was to establish contact with 6 of the 10 small CubeSat satellites that were hitching a ride on Artemis 1 (see Artemis 1's CubeSats, right).

Matt Cosby, director of space engineering at Goonhilly, says the station is probably in touch with between 10 and 20 spacecraft every day. Not all of these are deep-space missions, many are communications satellites around Earth that don't need the big 30-metre dishes. So, GES has a number of smaller five-metre dishes, many of them clustered together in an area of the site referred to as 'the antenna farm'. In total, there are around 40 antennas on the 160-acre site.

MULTIPURPOSE DISHES

Beyond deep-space communications, there are a number of other uses for the big dishes. For example, Goonhilly 3 (GHY-3) has been equipped with a cryogenic unit that cools the receiver to -265°C, just 8°C above absolute zero. This makes it highly sensitive to weak signals, so it can be used for radio astronomy, searching out celestial objects such as galaxies containing active supermassive black holes in their cores, or the remnants of exploded stars.

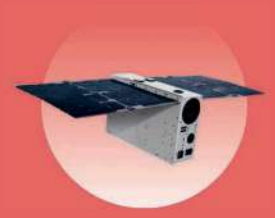
Sitting a radio telescope next to a deep-space communications dish went against the

NASA/JPL X4, ARGOTECH, NASA/DANIEL RUTTER, RECENTCONTRIBUTOR2000/WIKIPEDIA, SPACEPORT CORNWALL, GETTY IMAGES

ARTEMIS 1'S CUBESATS

Satellites can now be as small as a shoe box. Ten of these mini-satellites, known as CubeSats, were launched on the Artemis 1 mission in late 2022. Goonhilly is tracking these six:

BIOSENTINEL
Designed by NASA Ames Research Centre to spend 18 months studying the way radiation in space damages the DNA of living yeast cells.

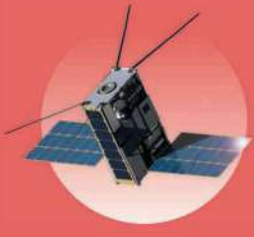


ARGOMOON
This was designed by the Italian Space Agency to autonomously record images of the rocket stage that propels Orion to the Moon and the deployment of the other CubeSats.

LUNAH-MAP
Designed by Arizona State University to investigate the lunar south pole for hydrogen deposits associated with water.

CUSP
The CubeSat for Solar Particles (CuSP) was designed by the SouthWest Research Institute, Texas, to study the radiation emanating from the Sun, known as space weather, which can affect electronics and living organisms.

NEASCOUT
The Near-Earth Asteroid Scout (NEAScout) CubeSat has been developed by NASA. It will unfurl an 86m² solar sail that will use the pressure of sunlight to propel the satellite to a small asteroid and reconnoitre its surface. Unfortunately, NEAScout did not make contact following its deployment.



LUNAR ICECUBE
Designed by NASA's Goddard Space Flight Center, the Busek Company and others to prospect the Moon for resources needed to build a lunar base.

orthodoxy. "Astronomers use radio telescopes to listen and they're listening intently. The comms people are just shouting at spacecraft, so it was assumed that you couldn't have them working together. But there are a lot of techniques in radio astronomy that can be used for deep-space communication, so learning from each other is quite useful," says Cosby.

Having such a sensitive receiver also means that they can listen for faint radar reflections too. This means that GHY-3 can be used to track space debris by detecting radar signals bouncing off the junk up there. Earlier this year, GES also began collaborating with companies Inmarsat and GMV Innovative Solutions to develop a satellite signal that could be beamed to GPS users to improve the system's accuracy. Known as the UK Space-Based Augmentation System (UKSBAS), it would boost the GPS signal's precision from several metres down to just a few centimetres.

MORE HISTORY TO MAKE

Satellite and deep-space communications are only set to increase in importance in the UK. In 2023, Richard Branson's Virgin Orbit company will perform the first satellite launch from British soil. A converted Boeing 747 plane will take off from Newquay's Spaceport Cornwall runway, carrying a rocket strapped to one of its wings. Once at an altitude of 10,668m (35,000ft), the aircraft will release the rocket, which will boost into orbit and deploy its satellites.

"We've been involved in the Spaceport Cornwall project since its inception," says Cosby. "And we're going to be tracking the rocket as it goes off." GES will then operate one of the satellites. The satellite, known as Amber-1, will be used to gather marine intelligence to help police activities such as piracy, illegal fishing and trafficking.

And the future holds even more excitement.

"I think, after a 50-year hiatus, there is renewed interest in going to the Moon," says Jones. He envisions expanding Goonhilly by building more facilities and becoming the communications provider for many of the missions that will go to the Moon.

For Jones, who took his childhood inspiration from the Apollo images beamed back through Goonhilly, it will be like coming full circle. And, it seems that there's a lot more space history for the Earth station to make. SF

by DR STUART CLARK (@DrStuClark)
Stuart is an astronomy journalist. His latest book is Beneath The Night: How The Stars Shaped The History Of Humankind *(£12.99, Guardian Faber).*

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Q&A

YOUR QUESTIONS ANSWERED

... WHY DO THE *VELOCIRAPTORS* IN *JURASSIC PARK* TAP THEIR CLAWS?
... DOES HITTING THE SNOOZE BUTTON ACTUALLY DO ANY GOOD?
... WHY DOES HONEY MAKE ME FEEL BETTER WHEN I'M UNDER THE WEATHER?
... WHAT IS A GREEN FLASH AND HOW CAN I SEE ONE?
... HOW IS MENTAL HEALTH BEING SUPPORTED IN AFRICA?
... WHY DO I LOOK SO DIFFERENT IN PHOTOS COMPARED TO HOW I LOOK IN THE MIRROR?
... HOW DOES ULTRASOUND WORK TO CREATE A PICTURE OF MY BABY?
... WHAT HAPPENED TO THE DADDY LONG LEGS INVASION WE WERE WARNED ABOUT?

Email your questions to
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DR NISH MANEK GP and medical expert
HAYLEY BENNETT Science writer
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PROF TREVOR COX Acoustics expert
DR HELEN PILCHER Biologist and science writer
PROF ALICE GREGORY Sleep expert

ILLUSTRATION: DANIEL BRIGHT

STACEY PENNINGTON, VIA EMAIL

WHY DOES MY SINGING SOUND SO GOOD IN THE SHOWER?

When you sing in a room, the sound lingers as it reflects back and forth between the walls. Each time the sound bounces off the room's surfaces, it gets a bit quieter as energy is lost. A bathroom contains lots of tiling and other surfaces that are hard and non-porous to make them easy to clean. These happen to reflect sound very efficiently, so it reverberates in the shower longer than in most other rooms. For example, a bedroom has soft furnishings, curtains and carpet that dampen the sound; these porous materials remove a lot of the sound energy at each reflection.

The strong reflected sound in the shower amplifies your voice, making you sound like a more powerful singer. Experiments have shown that louder music that surrounds you has a stronger emotional punch. But if you're a regular shower singer, you might have noticed that some notes are more impressive than others. This happens because some notes coincide with resonant frequencies in the bathroom and get more of a boost. (This is resonance of the air in the room, not the materials in the walls.)

The opposite of a shower, and a more extreme example of the plush bedroom, is an anechoic chamber. Every surface is covered with sound-absorbing foam wedges to ensure there are no reflections. Singing in there is hard work, and your voice sounds muffled and distant. Also, you can hear every tiny deficiency in your voice, because there's no other sound to hide them. In a shower, the reflections cause sound to linger. This creates a bloom that subtly smooths the transitions between notes, helping to hide imperfections and making you sound like a better singer. ***TC***

NATURE'S WEIRDEST CREATURES...

ARGONAUT OCTOPUS

A living argonaut is a rare sight indeed. They live in the open seas of the tropics and subtropics. Their delicate shells occasionally wash up on beaches and look similar to their relatives, the chambered nautiluses – hence their alternative name: the paper nautilus.

Argonauts are a type of octopus. People used to tell fabulous stories about them stealing shells from other animals, then floating across the waves, hoisting their arms into the air to act as sails and catch the breeze. This story makes some sense because, generally speaking, octopuses don't make shells. Their molluscan ancestors abandoned the habit millions of years ago, leaving it to their distant relatives, including clams and snails. The truth about argonaut octopuses finally came to light in the early 19th Century, when French scientist, Jeanne Villepreux-Power, studied argonauts in Sicily. She saw them building their shells, using silvery webs on the end of two arms.

There are four known argonaut species, with shells ranging from 5-30cm across. Only females make shells and use them as a mobile brood chamber for their eggs. In comparison, male argonauts are tiny. They have a detachable arm, laden with sperm, which they drop off and give to females. For a long time, scientists mistook these appendages for parasitic worms. *HS*

LEO JACOBS, NEWCASTLE

WHY DO THE *VELOCIRAPTORS* IN *JURASSIC PARK* TAP THEIR CLAWS?

When the *Velociraptors* in the *Jurassic Park* films start tapping their claws, it's a scene of pure movie horror. They're doing it as part of their hunting routine: to locate and frighten their prey. We don't know if this was a behaviour that actual dinosaurs engaged in, but it is plausible. Modern-day birds are known to tap their claws in various circumstances. Sometimes they do it to act like the Pied Piper: to wake up insects and herd them into a confined space where they can be easily eaten. Other times, pet birds tap their feet when they're ill or for reasons that are not understood. ***SB***

CHRIS HESS, VIA EMAIL

DOES HITTING THE SNOOZE BUTTON ACTUALLY DO ANY GOOD?

It's tricky to answer this question as there has been relatively little research on the topic. However, we are sometimes advised to avoid hitting the snooze button, because the act of waking repeatedly could stress the body or disrupt the sleep pattern.

Nonetheless, recent research by a team of scientists from Notre Dame University in the USA, found that the act of waking to multiple alarms might make the process easier in the morning (**bit.ly/SnoozeStudy**).

When we wake from a first alarm, we're more likely to be woken from deep sleep and experience a groggy state known as sleep inertia. If we fall back to sleep, however, we can enter a lighter stage of sleep from which it's then easier to wake. It's also possible that stress associated with repeat wakings could be helpful in counteracting sleep inertia.

If you struggle to wake up when your alarm goes off, though, it might be worth considering whether you're sleep deprived, as an earlier bedtime could be more helpful than automatically hitting snooze. ***AG***

JOHN HOOD, PENARTH

WHY DOES HONEY MAKE ME FEEL BETTER WHEN I'M UNDER THE WEATHER?

The first thing to say is using honey when you're under the weather is supported by the evidence and certainly won't do any harm. A review in the *British Medical Journal* in 2020 looked at 14 studies of almost 1,800 people with upper respiratory infections being treated with either honey or conventional methods (such as antihistamines, expectorants, cough suppressants and painkillers). Honey did appear to improve symptoms (especially the frequency and severity of cough) and in some cases was found to shorten the duration of symptoms by a day or two. The findings were only observational and honey isn't a cure, but it is safe for anyone over the age of one and is often kept as a staple in kitchen cupboards.

Why honey works is unclear, but it has long been thought to have antibacterial properties. In order to survive, bacteria need water and honey draws it away, which, in turn, damages the internal structures of the bacteria cells. That being said, a lot of cough and cold symptoms are caused by viruses rather than bacteria, so this wouldn't be a complete explanation for its beneficial effect. Honey also has anti-inflammatory properties and it has been suggested that, due to its viscous nature, it coats the throat causing a soothing effect.

The bottom line is that even though the evidence base isn't strong and we don't know exactly how it works, honey is cheap, readily available and has virtually no side effects. Also, given the concern about antibacterial resistance from overuse of antibiotics, it's certainly worth a try for some at-home self-care if you're feeling under the weather. ***NM***

ALEX MUSTARD/NATUREPL.COM, SHUTTERSTOCK, GETTY IMAGES

DEAR DOCTOR...

HEALTH QUESTIONS DEALT WITH BY OUR EXPERTS

ROLF BARRERA, VIA EMAIL

I MADE MY COFFEE TOO STRONG AND NOW IT FEELS LIKE MY HEART IS GETTING PUNCHED BY A GORILLA. IS THERE ANYTHING I CAN DO TO REVERSE THE EFFECT?

Unfortunately, there's nothing you can do to reverse the effect. You'll just have to wait out your caffeine overdose, which could take three to six hours. But there are things you can do to make the wait easier.

First (and hopefully this is an obvious point), don't consume any other caffeinated products today, so that includes things like cola, energy drinks and even chocolate. Drinking lots of water may help – it won't flush it out, as such, but an excess of caffeine can leave you dehydrated, which won't make you feel any better. Anecdotal evidence suggests eating something can help, especially foods rich in fibre.

If you're feeling anxious about the caffeine intake, chances are that your breathing is fast and shallow, and this will only increase your anxiety. Try to take slow, deliberate, deep breaths, which may help bring your heart rate down, or listen to some mindfulness tracks. Some suggest that a bit of exercise might help to burn off a bit of that extra energy – at the very least, it might distract you while the caffeine wears off.

The key is not to worry; a true caffeine overdose is very rare, so take heart knowing that you're unlikely to be doing any serious damage to yourself. It is, unfortunately, just a matter of waiting it out! *NM*

WILLARD COWEN, NORFOLK

WHAT IS A GREEN FLASH, AND HOW CAN I SEE ONE?

The elusive green flash is a phenomenon that occurs at sunset or sunrise, when the visible section of the Sun briefly turns a vibrant green. As the Sun crosses the horizon, its light is bent, or refracted, separating the different wavelengths. Shorter wavelengths refract more than longer wavelengths, so blue and violet light is scattered through the atmosphere and red, orange and yellow light is absorbed, leaving just green visible for a few seconds. Although rare, you're most likely to see a green flash somewhere that has a clear view of the horizon and little air pollution, such as over the ocean. ***CA***

CROWDSCIENCE

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HOW IS MENTAL HEALTH BEING SUPPORTED IN AFRICA?

Africa is home to 1.4 billion people, yet many of its 54 countries have little to no budget for mental health services. To make matters worse, trained psychiatrists are opting to leave the continent for better pay and support systems.

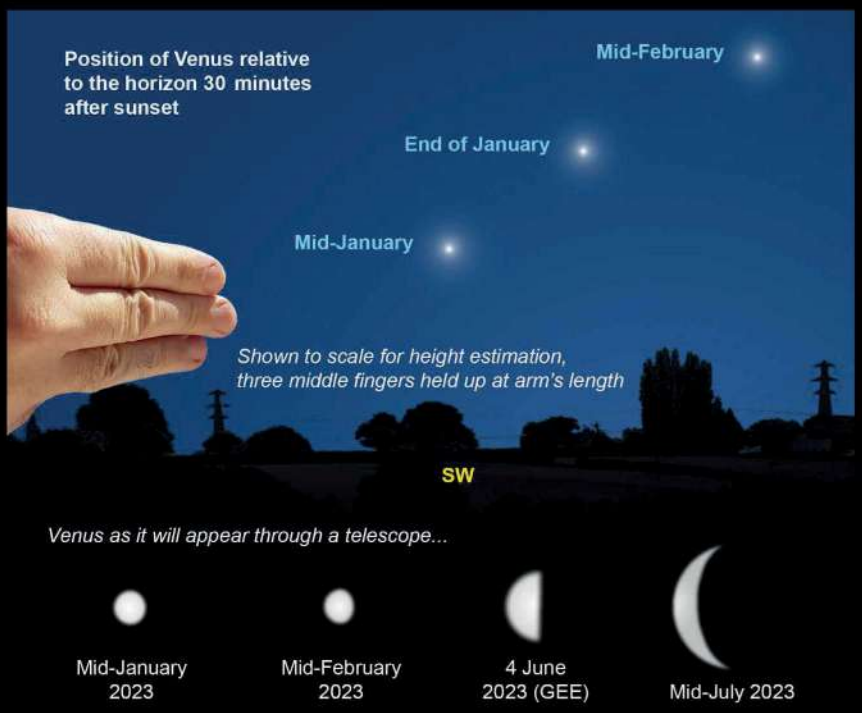
With a suicide rate above the global average and an estimated 116 million people affected by mental health conditions, professionals in Africa have their work cut out for them – especially with only one psychiatrist for every 500,000 people. To put that in perspective, the UK has one psychiatrist for roughly every 5,100.

Instead, local initiatives look to what are called lay health workers: community members trained in basic talking therapies, like cognitive behavioural therapy, and taught about common mental health problems. In Zimbabwe, these people sit in parks, shopping centres and community spaces and lend an ear to those in need. Called the Friendship Bench programme, the initiative has now spread elsewhere.

Yet stigma can still prevent people from seeking support. There is an association between mental illness and evil spirits, so when problems plague multiple generations it's believed to be caused by a curse over the family, not genetics. In some regions, one barrier to support is that the local language doesn't even have words for illnesses like depression, anxiety and schizophrenia – they all fall under the same term: 'madness'.

Breaking down these barriers to mental health support is a priority for African health ministers. In August 2022, they met at the World Health Organization's Regional Committee for Africa to produce a new strategy for mental healthcare, which hopes to see better funding, reporting and legislation by 2030. ***AA***

ASTRONOMY FOR BEGINNERS


Position of Venus relative to the horizon 30 minutes after sunset
Mid-February
End of January
Mid-January
Shown to scale for height estimation, three middle fingers held up at arm's length
SW
Venus as it will appear through a telescope...
Mid-January 2023
Mid-February 2023
4 June 2023 (GEE)
Mid-July 2023

VENUS: THE EVENING STAR

WHEN: FROM JANUARY TO JULY

Look west-southwest during mid-January, about 30 minutes after sunset, and you should see Venus, which sets 110 minutes after the Sun. By the end of the month, it'll set 135 minutes later, making the planet even easier to see.

Venus is the brightest planet visible from Earth, due to its proximity to the Sun and reflective, cloud-covered globe. Venus's orbit is around 70 per cent the size of Earth's, but follows an elliptical path around the Sun. When lined up with the Sun on the far side of this ellipse, Venus is at superior conjunction. After this, it slowly re-emerges into the evening twilight sky, becoming visible after sunset. Some re-emergences are better than others and 2023's should be good.

Through a telescope, as Venus emerges from the Sun's glare, it displays as a gibbous phase between half and fully lit. The phase reduces until Venus appears furthest from the Sun in the evening sky, a position known as greatest eastern elongation (GEE). The next GEE occurs on 4 June, when, through a telescope, Venus should appear at dichotomy or 50 per cent lit. However, the thick Venusian atmosphere interferes and brings the appearance of dichotomy through a telescope forward a few days.

After GEE, Venus appears to head back towards the Sun, moving along part of its orbit closest to Earth. As a result, the phase changes quickly and, through a telescope, Venus appears as a rapidly diminishing crescent.

Eventually, it gets too close to the Sun to see safely, before finally lining up with the Sun on the Earth-side of its orbit. Known as inferior conjunction, this next occurs on 13 Aug 2023. From there, the 'evening star' will re-emerge into the morning sky, becoming the 'morning star' once more, even though it is, of course, a planet! ***PL***

ALAMY, GETTY IMAGES, COSTA JUTA/FRIENDSHIP BENCH ILLUSTRATION: PETE LAWRENCE

LELIA FAULKNER, VIA EMAIL

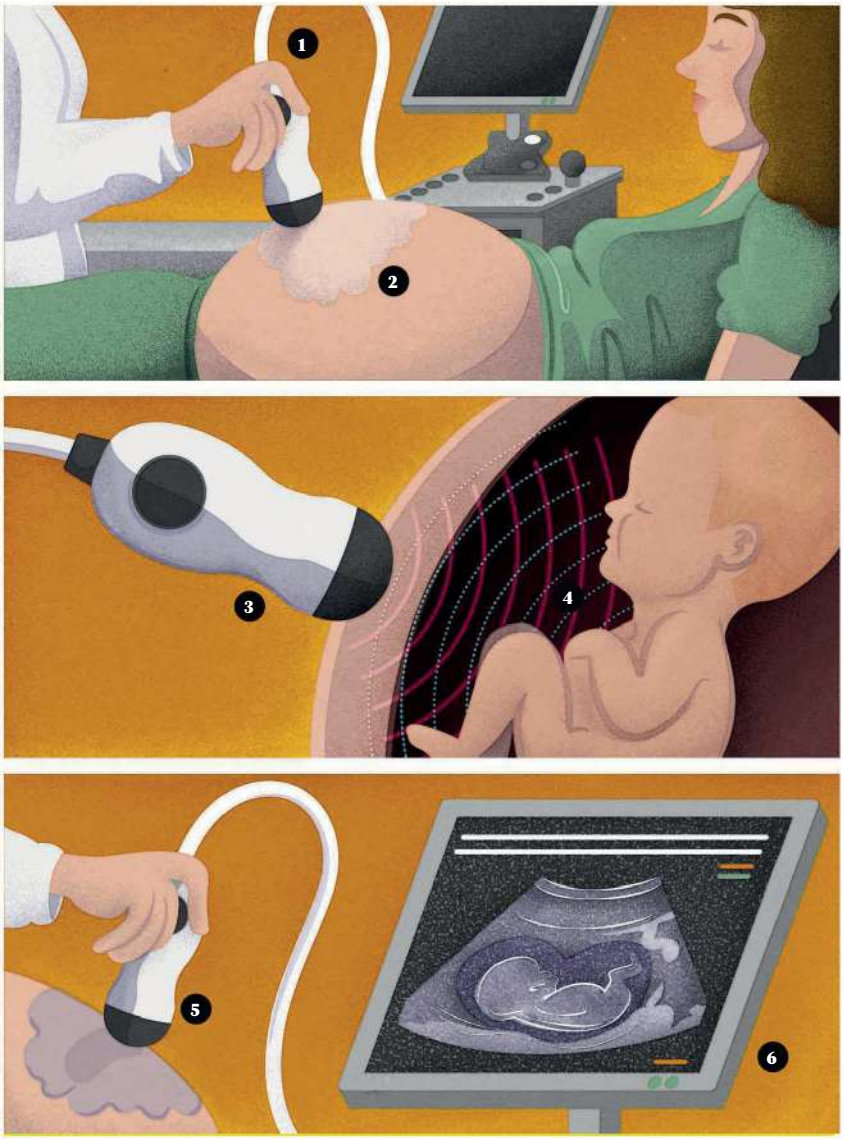
WHY DO I LOOK SO DIFFERENT IN PHOTOS COMPARED TO HOW I LOOK IN THE MIRROR?

Photos can catch you from all sorts of angles, some less flattering than others, and in the midst of a multitude of emotional expressions, whereas you usually look at yourself straight on in the mirror, with a neutral or posed expression.

But there's more to it than that. Most people's faces are surprisingly asymmetrical, whether it's a curve to the nose, a parting in your hair, a mole on a cheek or some other quirk. When you look in the mirror, these left-right discrepancies are reversed, unlike in photos. Selfies can be especially distorting, making your nose and face look longer, for instance.

Crucially, it's the mirror image that you're used to – most of us see ourselves in the mirror many times a day, such as when brushing our teeth, shaving or washing our hands. So, it's this reversed image that we're familiar with and come to see as our true appearance. This fact then interacts with a psychological phenomenon called the 'mere exposure effect', which describes the way we tend to develop a liking for the familiar. This can influence how you feel about your appearance as you see it in the mirror, compared to photographs. The reflection staring back at you might not be perfect, but at least it's what you're used to.

A recent study used a special 'non-reversing mirror' (that simulates your appearance in photos) and a normal mirror to test how people contemplating cosmetic surgery felt about their looks. The researchers at the Cleveland Clinic Foundation found that patients felt more positively about their faces when using the normal mirror rather than the non-reversing kind. This could be important because cosmetic surgeons typically use photos of a patient to discuss their appearance, which is likely to negatively bias their impression of themselves and encourage more drastic surgery. ***CJ***



KATE WILDMAN, VIA EMAIL

HOW DOES ULTRASOUND WORK TO CREATE A PICTURE OF MY BABY?

1 The handheld device that the ultrasound technician places on your pregnant belly is called a transducer. It contains piezoelectric materials that can convert electrical energy into sound. When ultrasound was first invented, these materials were natural crystals, like the quartz used in analogue watches, but today's ultrasound transducers usually contain human-made ceramics, such as lead zirconate titanate.

2 The first thing the technician does is cover your belly with a gel, to prevent air from getting between the transducer and your skin, as air bubbles can block ultrasound waves.

3 When the transducer is turned on, the electrical current that runs to the piezoelectric crystals makes them contract and expand more than 20,000 times per second, causing a vibration that generates a sound. At a pitch or frequency of 3-12 million Hertz, the sound is too high for you or your baby to hear – hence 'ultrasound'. Humans can only hear up to 20,000 Hertz.

4 The technician uses the transducer to direct a beam of ultrasound waves into your body. The waves travel through your tissues at a speed of around 1,540 metres per second and so very quickly find your uterus and baby in their path. Anywhere there is a change or break in tissue structure, the ultrasound waves are reflected back at the transducer.

5 The transducer picks up the reflected waves and converts them into electrical signals. Depending on where the waves were reflected, the distance each one has to travel to reach the transducer is slightly different and these differences can be used to build the image you see on the screen. The stronger the reflected wave (amplitude) and the quicker it reaches the transducer, the higher the resolution of the image.

6 Computer software processes the information transmitted in the electrical signals. It does this very rapidly, meaning you see the picture of your baby in real time. ***HB***

GERARD HIGGINS, LOUGHBOROUGH

WHAT HAPPENED TO THE DADDY LONG LEGS INVASION WE WERE WARNED ABOUT?

In September, the tabloids warned of an 'invasion,' as 200 billion daddy long legs were predicted to emerge and storm our homes. Their synchronised hatching was said to be spurred by an unseasonably warm patch of weather, but aside from the odd gangly straggler, it seems the invasion never occurred. So, what happened?

In the UK, the two species of 'daddy' most likely to enter our homes (the common European cranefly and the marsh cranefly) had already been and gone. The insects spend most of their lives as soil-dwelling larvae, known as leatherjackets. They feed on plant roots and detritus, then they pupate for a week or two, before hatching in the late summer and early autumn. Larvae can die in waterlogged soils, so if it rains heavily over the summer, the number of hatchlings can be affected. This summer was one of the hottest and driest on record, but no one knows what effect this had on our craneflies, because the species are not rigorously monitored.

What we do know is that craneflies play a vital role in ecosystems. Cranefly larvae help to maintain soil health and are a food source for hedgehogs, badgers and foxes. Meanwhile, adult craneflies are eaten by birds and bats. Adults live for just 10 to 15 days and in some species, the females emerge carrying mature eggs. With males on standby, intercourse can happen within minutes of a female emerging and can last for hours.

Sometimes, individuals get distracted by the light and warmth of a human house, and find their way inside. They're annoying, but not dangerous. Contrary to rumour, our British daddy long legs are not venomous, and do not bite or sting. They can readily be scooped up in a container or a gentle pair of hands, before being released back outside. ***HP***

IMOGEN PAYNE, LONDON

DO WE KNOW WHAT CONTINENT THE DINOSAURS EVOLVED ON?

When the first dinosaurs appeared around 230-240 million years ago, during the Triassic Period, all land was gathered into the supercontinent Pangaea. The oldest dinosaur fossils appear in places like Argentina, Brazil and Zimbabwe, which, at that time, were close together in the higher latitudes of southern Pangaea. While there is always the risk that the oldest known fossils don't necessarily record the first dinosaurs, the fact that Triassic dinosaurs are commonly found in these places, but not in more northern parts of Pangaea, is a good sign that dinosaurs were natives of the Pangaean south. It seemingly took dinosaurs millions of years to migrate across Pangaea, which appears odd as there would have been no oceans or other physical barriers to stop them. Instead, it seems they were constrained by climate. During much of the Triassic, the tropical and subtropical regions of Pangaea were hot and arid. The first dinosaurs of southern Pangaea, which lived in a more temperate environment of cooler temperatures and greater rainfall, were probably marooned and only able to move into the tropics when climates ameliorated later in the Triassic. ***SB***

QUESTION OF THE MONTH

TONY BALONEY VIA EMAIL

IS THERE A DINO-DEATH ASSEMBLAGE FROM WHEN THE ASTEROID HIT?

At the end of the Cretaceous, about 66 million years ago, a 10km-wide asteroid hit Earth. It triggered a chain reaction of earthquakes, tsunamis and wildfires, followed by a 'nuclear winter' of several years, as the dust from the impact and fires blocked out the Sun. Dinosaurs couldn't cope with the sudden devastation and all of them (except a few birds) went extinct. Many would have died instantaneously, others in the days and weeks after the impact, and the last ones after a few thousand years of struggling to survive.

So where are the bodies? With so many victims, some of their remains would have fossilised. But finding and dating them to the exact time the asteroid hit is exceedingly difficult.

There is one site in North Dakota in the US, called Tanis, that may contain remains of dinosaurs, turtles and fish that died soon after the asteroid hit. The site has been profiled on TV and in the press, but only in a few peer-reviewed research papers. These papers provide convincing evidence that the fish died soon after the asteroid hit, as their gills are full of spherules – tiny glass particles that formed from material liquefied by the asteroid that rained back to Earth and solidified soon after. The next step is proving that the dinos at the site died soon after the asteroid, too. *SB*

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WINNER

The winner of next issue's *Question Of The Month* wins **two science fiction books** from author Gareth Worthington and Dropship Publishing (an imprint of Vesuvian Media) worth £49.98. The prize includes medical technothriller *Condition Black*, and a limited edition hardback of the space adventure *Dark Dweller*. **vesuvianmedia.com**

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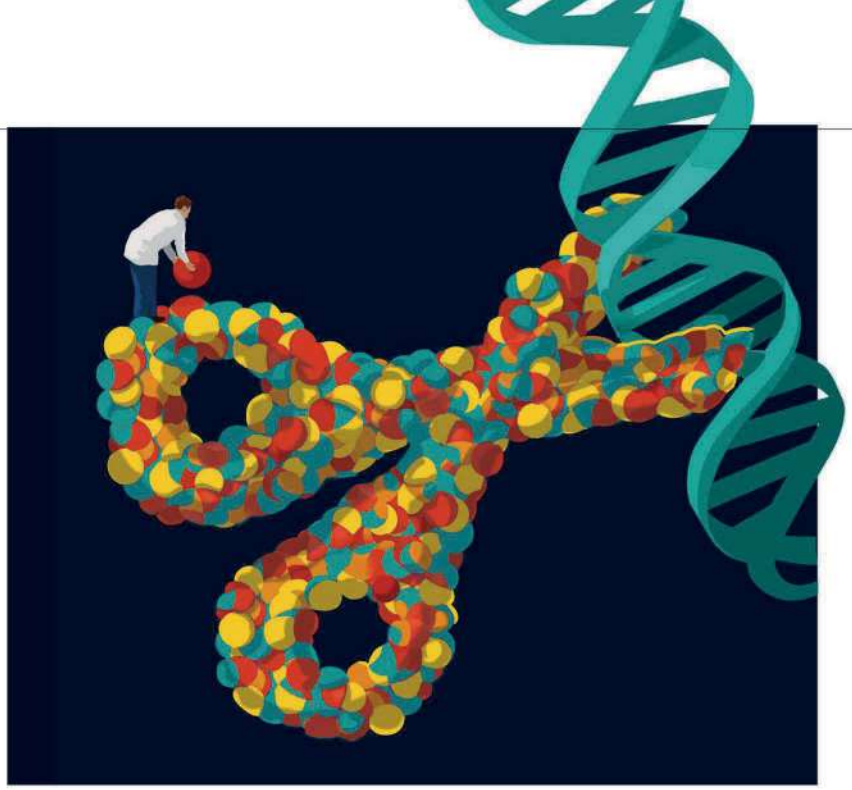
CRISPR

THE EXPLAINER

THE GENOME-EDITING TOOL THAT IS CHANGING THE BUILDING BLOCKS OF LIFE ITSELF

ILLUSTRATIONS: SAM FALCONER



HOW WAS CRISPR DISCOVERED?

Genuine eureka moments are rare in science, but one occurred a decade ago when research into a curious function of bacteria immunology exploded into a Nobel Prize-winning discovery. The 2012 paper by Jennifer Doudna and Emmanuelle Charpentier is already recognised as a landmark of science.

Researchers had been piecing together information about CRISPR (clustered regularly interspaced short palindromic repeats) since the 1980s. In nature, it's a molecular defence mechanism that bacteria use to detect and destroy the DNA of an invading virus, like a set of microscopic scissors. When a bacterium is infected, the 'scissors' cut and paste a segment of the virus DNA and insert it into its own genome. This trains the system to recognise that DNA and destroy it.

The major breakthrough came when scientists isolated the specific enzymes and RNA (ribonucleic acid) that made up the genetic scissors. Reproducing it in a lab turned CRISPR into a tool that accelerated the speed of biological research. It was a simple way to edit the genomes of any living thing.

HOW IS THE TECHNOLOGY AFFECTING MEDICINE?

A number of genetic disorders are caused by a mutation in a single gene. The power (and precision) of CRISPR is allowing scientists to uproot those conditions from the human genome in a single, life-changing treatment. CRISPR therapies for blood disorders, like sickle cell disease and beta thalassemia, were among the first to reach human trials, and early results have been encouraging. Patients are recovering from potentially fatal illnesses that caused chronic pain and required regular treatment. The fact is, just 10 years on from its discovery, CRISPR is saving people's lives. The first CRISPR therapies for blood disorders could be approved in 2023.

Practically any disease with a genetic component could potentially have a CRISPR treatment. Trials are underway for conditions as diverse as blindness, cancer, diabetes and HIV/AIDS. Illnesses such as heart disease and dementia could also be targeted, because researchers aren't just studying genes that cause disease – they're also looking for ways to insert protective DNA into the human genome.

WHAT ABOUT VACCINES?

The CRISPR-Cas9 tool is sometimes described as a 'wanted' poster that's hung in an organism's immune system. On this is the likeness of a virus, teaching the immune system to recognise the potential invader.

Vaccines of various kinds are designed to do the same job: to give your immune system a heads-up about potential invaders. Thanks to its precision and ease of use, CRISPR can help us make new kinds of vaccines. During the COVID-19 pandemic, CRISPR was used to develop some of the mRNA vaccines, and it's now being used to accelerate new ones, including one for malaria. Working with the parasite *Plasmodium falciparum*, which causes malaria, Washington-based scientists deleted three genes that are needed to infect humans. After being bitten by mosquitoes containing the CRISPR-edited parasite, people were protected against malaria for a few weeks, thanks to antibodies produced by the body.

HOW IS CRISPR CHANGING FOOD AND AGRICULTURE?

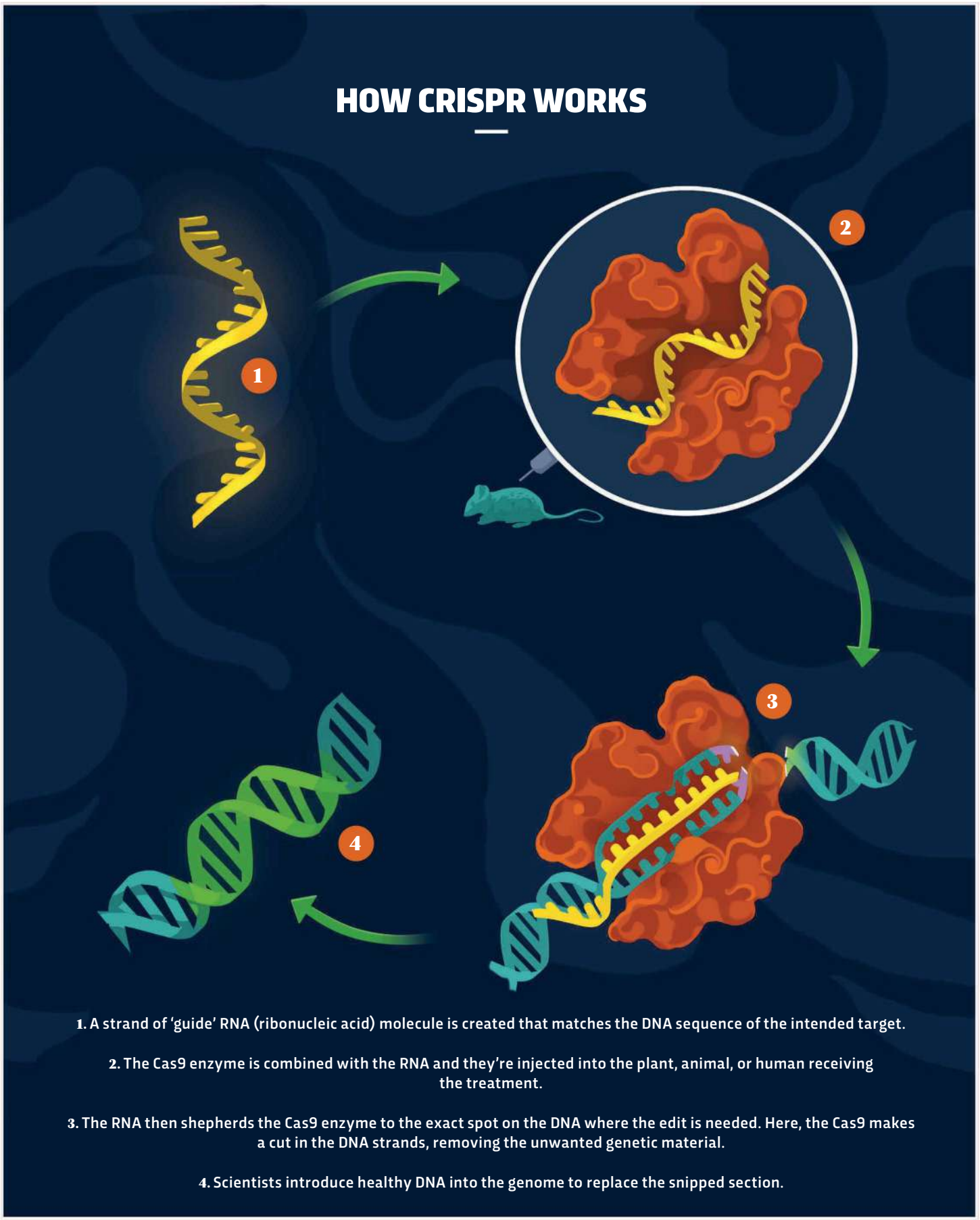
Is anyone peckish for a spicy tomato? How about some nuts that won't rattle your allergies? Or a triple-stack burger that you can enjoy without sending your cholesterol into orbit? Those are some of the delectable possibilities on the menu as researchers begin to use CRISPR to produce foods with unusual traits.

In agriculture, CRISPR is being used to produce crops that are pest- or drought-resistant. With demand for food set to soar, researchers are looking to create higher-yield crops by silencing genes that restrain growth.

Biotech firms are racing to develop foods that make us healthier or safer, and researchers are developing nuts, wheat, and other foods that are edited to remove allergens. CRISPR-edited tomatoes are already on sale in Japan.

CRISPR is also being used to develop lab-grown meat, and research shows CRISPR reduces LDL (low-density lipoprotein) cholesterol in monkeys by 70 per cent in two weeks.

"The fact is, just 10 years on from its discovery, CRISPR is saving people's lives"


HOW CRISPR WORKS
1
2
3
4
1. A strand of 'guide' RNA (ribonucleic acid) molecule is created that matches the DNA sequence of the intended target.
2. The Cas9 enzyme is combined with the RNA and they're injected into the plant, animal, or human receiving the treatment.
3. The RNA then shepherds the Cas9 enzyme to the exact spot on the DNA where the edit is needed. Here, the Cas9 makes a cut in the DNA strands, removing the unwanted genetic material.
4. Scientists introduce healthy DNA into the genome to replace the snipped section.

ILLUSTRATIONS: SAM FALCONER

"By editing the genome of the living species in the places where it differs to the extinct species, researchers believe they could bring animals back from the dead – or at least create a hybrid that shares some of their DNA"

COULD CRISPR BRING EXTINCT CREATURES BACK TO LIFE?

CRISPR holds the potential to take surviving DNA from an extinct species and compare it with the genome of a related, living one. By editing the genome of the living species in the places where it differs, researchers believe they could bring animals back from the dead – or create a hybrid that shares some DNA.

The most iconic example is the woolly mammoth, which died out around 10,000 years ago, and scientists aren't certain whether they were hunted to the brink by humans, or struggled to survive in Earth's rising temperatures. Either way, their fate may not be sealed. A number of preserved specimens have been found buried in ice and scientists have not only extracted mammoth DNA, but they've also sequenced the entire genome.

Now, researchers are trying to return mammoths to the Arctic tundra. Start-up Colossal is using CRISPR to genetically modify the genomes of Asian elephants so they have cold-adapted traits of their long-dead cousins, like smaller ears and more body fat. It believes the first calves will be born within five years.

Projects to revive animals that went extinct more recently, like the thylacine and the passenger pigeon, are also underway.

WHAT ARE THE CHALLENGES WITH CRISPR?

CRISPR is sometimes described as 'easy'. It may not be rocket science, but funnily enough, genome editing is still a complex process and it's very expensive, especially when it comes to curing diseases. Researchers are refining CRISPR delivery mechanisms, looking for enzymes that may be more effective than Cas9 and trying to limit what are known as 'off-target effects'. These occur when the process of editing affects not just the target DNA but potentially other genes within the organism as well.

Perhaps the biggest challenges are not technical, however, but ethical. Gene editing has long carried the stigma of 'playing God' and researchers interrogate their own work against some of the questions that are often asked about the technology and its use. Will it lead to greater health inequality as the rich access exclusive treatments? Should you target germline cells, where any edits made are also passed onto the next generation? And as it becomes more accessible, how do you regulate the technology for human healthcare and not human enhancement?

WHAT ARE CRISPR BABIES?

In 2018, twin girls were born in China who became known as the 'CRISPR babies' – the world's first genome-edited children. Biophysicist He Jiankui engineered mutations in human embryos, which were later implanted into a woman. He claimed to have disabled a particular gene to give them protection against HIV.

He was jailed in China and condemned by the scientific community for crossing an ethical line by editing the human germline – the mutations he made would be passed on to the girls' future children. The rogue scientist was also criticised for not following the normal safety procedures and fuelling the idea of 'designer' babies – the notion that gene editing will allow future parents to choose everything, from their children's eye colour to their intelligence.

Ethicists warn that without careful regulation, genome editing could lead to a two-tier society, split between those who are edited and those who are not.

"Ethicists warn that without careful regulation, genome editing could lead to a two-tier society"

A GENETIC REVOLUTION

1987

The CRISPR mechanism is first described in scientific literature.

2000-2002

More clustered repeats of DNA are found in bacteria and archaea. The term Cas9 is coined (where Cas comes from CRISPR-associated proteins).

2005-2008

We begin to learn how CRISPR and Cas9 protect bacteria from viruses.

2012

Emmanuelle Charpentier, Jennifer Doudna and colleagues publish their landmark paper on CRISPR-Cas9 as a genome-editing tool.

2016

The first CRISPR-based therapy is used to treat somebody, a patient with lung cancer.

2018

Biophysicist He Jiankui announces the so-called CRISPR babies, children born from genome-edited embryos.

2020

Charpentier and Doudna are awarded the Nobel Prize in Chemistry for their work on CRISPR.

2021

The US Food and Drug Administration approves the first CRISPR therapy for sickle cell disease.

IAN TAYLOR
Ian is a freelance science and health writer, and former editor at BBC Science Focus.

SIX WAYS CRISPR COULD FIGHT CLIMATE CHANGE

Food

Climate change is already affecting yields of crops. GM foods aren't to everyone's taste, but scientists are using CRISPR to develop crops resistant to drought, heat and floods.

Biofuel

Gene-edited biofuels could play a key role in providing clean energy. CRISPR has made it possible to produce double the amount of biodiesel from phototropic algae.

Plants

Californian scientists are using CRISPR to develop plants that remove CO_2 from the atmosphere, thanks to improved photosynthesis and roots that deposit carbon deeper into the soil.

Microbes

Jennifer Doudna, one of the joint discoverers of CRISPR, has spoken about the potential for CRISPR-modified soils and microbes to extract more carbon from the atmosphere.

Coral reefs

US scientists are using CRISPR to study genes in coral that affect heat tolerance. They hope it will help conservation efforts as reefs feel the impact of rising sea temperatures and ocean acidification.

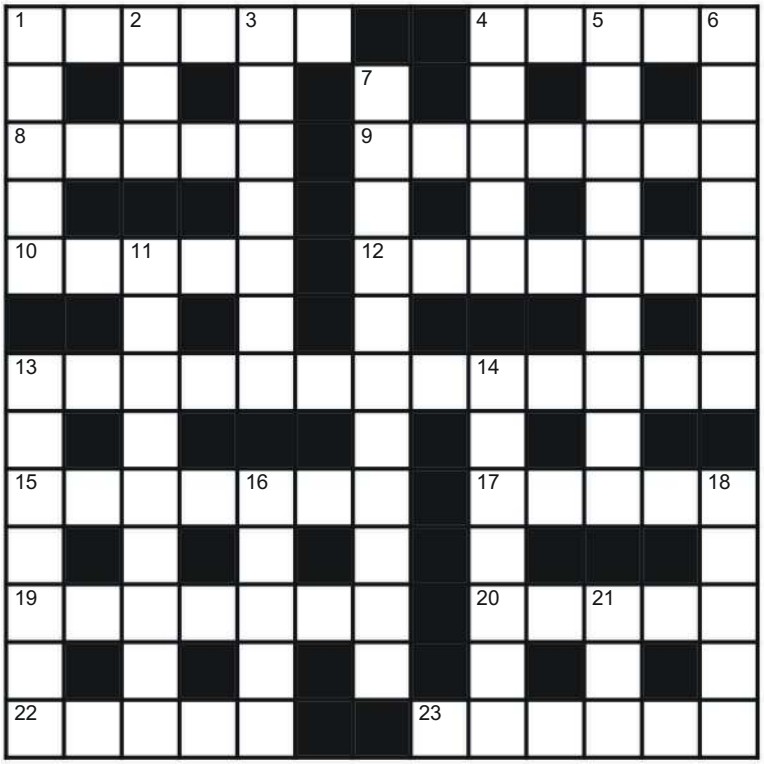
Methane

Methane released during rice production makes up 2 per cent of global greenhouse emissions. CRISPR is being used to create crops and livestock that release less methane.

ILLUSTRATIONS: SAM FALCONER

CROSSWORD

PENCILS AT THE READY!



ACROSS

1 Nocturnal visitor getting bishop to budge awkwardly (6)
4 Total returned, containing copper secretion (5)
8 Show agreement about the heartless and famous (5)
9 Liberate group at no cost (3,4)
10 Following son, we're off to get some plumbing (5)
12 Former pupil finding setting vulgar (7)
13 Occasional piece of furniture that displays every element (8,5)
15 Consider what a mirror does (7)
17 Should have purchased missing front (5)
19 Left in charge next to old porch (7)
20 Small cake has so upset ship's officer (5)
22 Vote in the middle of the lecture (5)
23 Thrifty fellow covering a lake (6)

DOWN

1 Coach gets no new extra money (5)
2 Dorothy comes to a full stop (3)
3 Experience ground trembling with energy (7)
4 Manuscript about the distilled alcohol (5)
5 Transport favourite keys in container (9)
6 Glimpse present and listen! (3,4)
7 Relationship in guild (11)
11 Employees function alongside police (9)
13 Savoury snack found in hat (4,3)
14 Implement check for strip of icons (7)
16 Live like a headless chauvinist (5)
18 Working a lot around noon with a key (5)
21 Small silver sink (3)

ANSWERS For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

NEXT ISSUE

SAVE THE WHITE RHINO

The last two northern white rhinos are both female. But science says the species can survive.

GETTY IMAGES

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SF

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POPCORN SCIENCE

Are we ready for first contact?

Could we happily accommodate aliens in our lives, just like in the *Star Trek* universe?

by **STEPHEN KELLY**

The year is 2063 and brilliant scientist Zefram Cochrane has just carried out the first successful test flight of a 'warp engine', unlocking the seemingly impossible possibilities of faster-than-light travel. The warp signature is detected by a nearby Vulcan ship, the crew of which determine that humanity has finally matured enough for first contact. And that – in the universe of *Star Trek* – is how we become aware of the existence of aliens.

"I don't think you could rule out such a scenario," says Michael Garrett, director of the Jodrell Bank Centre for Astrophysics and the current chair of the International Academy of Astronautics Search for Extraterrestrial Intelligence (IAA SETI) Permanent Committee. "Any alien civilisation is likely to be significantly more advanced than we are. They could be cloaked."

According to Garrett, our knowledge of intelligent alien life is more likely to come from an observatory receiving an extraterrestrial signal rather than the sudden arrival of a ship. In that scenario, organisations signed up to SETI have their own first contact protocol. "The first step is verification of the signal by an independent observatory," says Garrett, who explains that the discovery should be kept secret until wider verification takes place. The discoverer's government, and eventually the United Nations, should then be informed, with the news of the contact announced to the public soon after. That is, at least, how it is meant to go.

"Whether the protocol would actually be adopted, I have some doubts," says Garrett. "If the signal is information-rich, for example, I think that has much larger consequences than a signal that just points towards there being an intelligent civilisation somewhere out there. It will have a value that will become understood by governments very quickly. On some level, scientists have to protect themselves. What is written in the protocols may not be what happens in practice."

Depending on the nature of the alien signal, or whether we would even be able to understand or translate it, there is also the question of whether we would respond.

"It is very difficult to stop people transmitting signals into space," says Garrett. "And if you had a really advanced civilisation out there, it might not take a lot to transmit a signal that they could detect. You will no doubt have small groups of enthusiasts and amateurs that would send signals. But what entitles any group, individual or country to send out messages on behalf of the whole planet? That's where the United Nations' involvement is important, although currently the UN does not have a view on this."

In *Star Trek*, the revelation that we are not alone, that intelligent life exists beyond the stars, leads to a profound change in how the human race sees itself. It becomes more enlightened, more unified and ultimately more motivated by exploration than war or greed. Whether we would react in the same way remains to be seen, however.

"I think a lot depends on distance," says Garrett. "If the aliens are within the Solar System, then I think people will be worried. But if they're on the other side of the Galaxy, I think people would be excited by that. Some religious organisations may need to change their doctrines, but most religions are pretty good at accommodating things as they arise. I would like to think that if we find another civilisation out there, that it would accelerate our own political maturity, ethics and morality. But that's the beauty of *Star Trek* – it gives us something to aspire to." **SF**

VERDICT

The protocols are in place for first contact, and most people would be excited to make friends with pointy-eared, super-smart aliens.

by **STEPHEN KELLY** *(@StephenPKelly)*
Stephen is a culture and science writer, specialising in television and film.

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